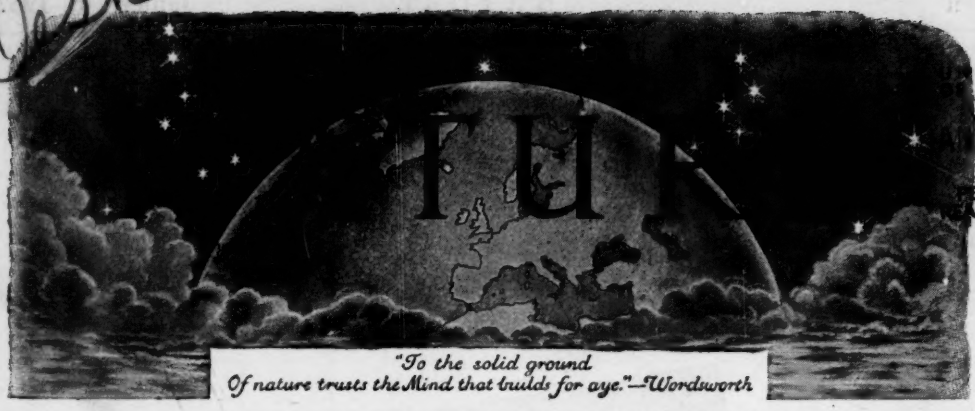

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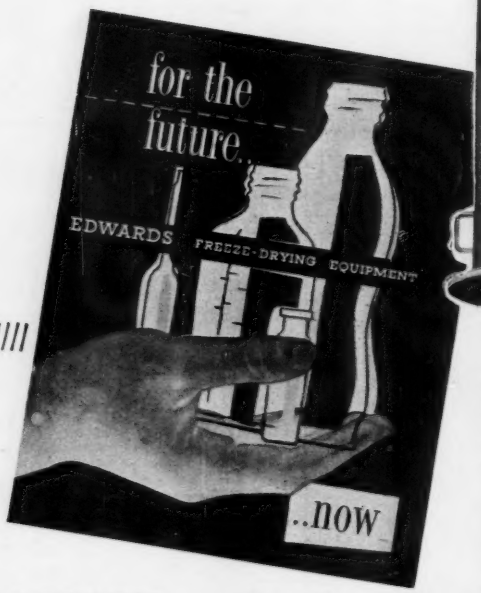

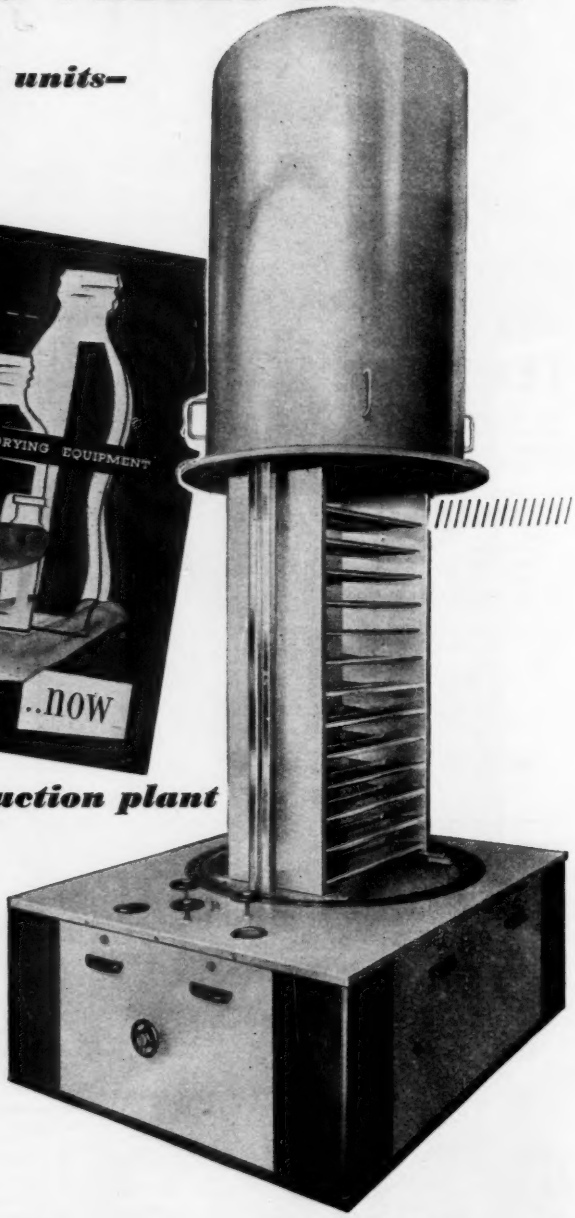

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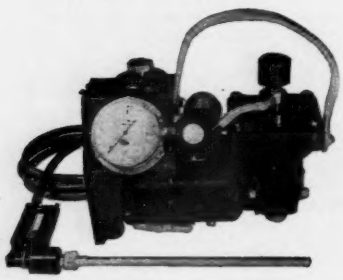

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SCIENTIFIC, TECHNOLOGICAL AND TECHNICAL MAN-POWER

THE debate on engineering and scientific education which Lord Simon initiated in the House of Lords on November 21 was prompted as much by the determined drive in scientific and technical education which the U.S.S.R. is making as by the White Paper on Technical Education and the more recent report on scientific and engineering man-power in Great Britain, to both of which, as well as to the Government's proposals for the expansion of the Imperial College of Science and Technology, Lord Simon referred. The debate would in any event have been notable for Lord Salisbury's speech, which included a statement regarding the expansion of scientific and technological education at the universities which the Financial Secretary to the Treasury made in the House of Commons on the same day. It was no less notable for a number of outstanding speeches which brought into their proper perspective several factors to which the White Paper on Technical Education, the report on scientific and engineering man-power and the subsequent report from the Advisory Council on Scientific Policy have scarcely given sufficient attention.

Lord Salisbury summarized the special measures which the Government has taken since 1952 to develop technological studies at the universities of Great Britain and pointed out that the twelve institutions to benefit from the £4,300,000 authorized in June 1956 for further buildings for science and technology included the University of Liverpool, University College, London, and Queen Mary College, London, which were not mentioned in the statement of December 1954. He said that the universities have already made proposals to the University Grants Committee which will increase the number of students from 84,000 in the academic year 1955–56 to 106,000 by the mid-1960's, and it was expected that about two-thirds of this increase would study science or technology. Lord Chorley thought that the largest proportion of them should be studying technology. To provide the new accommodation required, the Chancellor of the Exchequer had authorized university building projects to the value of £10,400,000 to be started in 1957, £12 million in 1958 and a further £12 million in 1959, in addition to the large sums required for the expansion of the Imperial College, thus doubling the present rate.

These amounts, Lord Salisbury said, were only instalments of what will be needed over a longer term, and the Government believes that the universities should be encouraged to expand even more. The University Grants Committee has advised that a larger expansion is desirable if resources can be made available and, in consultation with the Committee, the Government contemplates inviting the universities to consider still further development to meet national needs. The Government intends to ensure that the universities and technical colleges together will be able to produce at least the number of qualified scientists and engineers which the Committee on Scientific Man-power estimates to be needed during the next ten to fifteen years.

In making his statement in the House of Commons, Mr. H. Brooke added, in reply to questions, that the building plans would include provision for facilities for social life for this increased number of students, and also for increases in staff. It is also the Government's desire that all who have the mental and general abilities to profit by a university education should have the opportunity. It is a co-ordinated policy, and the Chancellor of the Exchequer is in close touch with the Minister of Education and any other Ministers who might be concerned to ensure that the best use is made of the talent of school leavers.

The Lord President of the Council equally emphasized that this is a concerted policy, and while largely confirming Lord Simon's remarks as to Russian industrial power, he pointed out that we may do serious harm to the economy of Britain as a whole if we try to model our plans for scientific man-power on those of another country with different needs and conditions. He suggested that each and every industry should consider most carefully for itself the implications of the figures disclosed in the recent report on scientific man-power. He accepted as a reasonable estimate the conclusion that we should double the output of scientists and engineers in Britain in the next fifteen years: this figure includes an allowance for emigration and training students from overseas, and it is recognized that a greater increase is likely to be needed of those trained in the engineering as distinct from the basic sciences. As regards technical education, Lord Salisbury observed that the newly created colleges of advanced technology will, in the Government's plan, play a major part in increasing the number of professional engineers. He expressed the hope that these institutions will increase their postgraduate studies and develop a strong line in applied research and consulting work. He mentioned that, of the eight such colleges provisionally designated, the designations of Battersea, Birmingham and Salford have already been confirmed. Sandwich courses have increased in number from 103 in 1955 to 168 in the current session.

Lord Salisbury admitted that an acute difficulty in the development of technical colleges is the question of teachers, and that this is of course one reason why the decision to designate another college of advanced technology within a few miles of the Manchester College of Science and Technology is disturbing. He also said that more than £40 million of the five-year building programme in England and Wales has already been approved and will be started on the site by April 1959, while the £8 million worth of projects already planned to start in Scotland within the next few years includes new local technical colleges at Edinburgh, Glasgow, Lanarkshire, Aber-

deen, Dundee and elsewhere, showing that the education authorities in Scotland are determined to make good the deficiencies of facilities at the lower levels, where technical education in Scotland most needs to expand.

Lord Simon had stressed the importance of Britain being able to supply more graduate engineers and scientists for technical aid to the under-developed countries to enable Britain to meet the challenge of the U.S.S.R.; and, quoting the example of the Atomic Energy Authority and some four of the great technical firms, he urged the need for giving both scientists and engineers more responsibility. This latter point was strongly supported by Lord Weeks, who, like Lord Silkin, also raised the question of status and prestige, urging that a new outlook and attitude are required on the part of parents and teachers if more of the brighter boys and girls are to be attracted to a scientific or technical career. Lord Chorley also emphasized this point, relating it rather to the shortage of science teachers in the schools and to the great reservoir of ability in the girls' schools. Lord Woolton likewise observed that, if industry wants to recruit more first-class scientists and engineers, it must make their prospects perfectly clear, and in the smaller firms there is much room for encouragement to the scientists to occupy more important positions than at present appear to be open to them.

While the Government's programme and Lord Home's reply on the debate were warmly welcomed, there were some misgivings. The most serious were in respect, first of the supply of students and next in regard to teachers, both in the schools and in the universities and colleges. There were also doubts about the balance between technical and technological or university education, while Lord Chorley, like Lord Waverley and Lord Cherwell, believes that technological education should be a function of the universities and not of the technical colleges. As regards the supply of students, it is generally admitted that more could be done to attract boys and girls to a career in science and technology. Tribute was paid to the good results which have already come from the Industrial Fund established a year ago, and in paying tribute to the help which industry has given, Lord Home said that, whereas at the higher level of the General Certificate of Education, passes in English and history have gone up by 12 per cent compared with 1950, those in chemistry have gone up 27 per cent and in physics 48 per cent; while in the boys' grammar schools, about 60 per cent of those in sixth forms are now specializing in mathematics or science, compared with 50 per cent from the public schools, and that 51 per cent of State scholars in 1955 are reading mathematics or science. Lord Caldecote also paid a warm tribute to the Industrial Fund, and Lord Weeks referred to it with appreciation.

In regard to teachers, as Lord Godber remarked, interest in science subjects cannot be aroused by teachers who have not themselves been encouraged to see these subjects as interesting disciplines. Lord Home agreed there is much to be done, officially and unofficially, in the way of propaganda in order to ensure that the opportunities to be provided are fully used. Lord Falmouth indeed had pointed out that in 1954 there were still several hundred unfilled places in technical courses in colleges in Britain.

But the influence of science teachers and the recruitment of sufficient first-class science teachers, though critical, is only a part of the problem. Equally important is the question of university teachers, including teachers of technology. The question of staff indeed is, as Lord Caldecote remarked, likely to be far more difficult than that of buildings, and it bears strongly on the other major question—that of balance. Lord Salisbury himself noted that industry is already helping in this respect; but neither his speech nor that of Lord Home indicated how closely the supply of university teachers shapes the expansion of the universities and colleges of technology as well as of the technical colleges.

Prof. R. V. Jones recently discussed the question of scientists for the universities in the *Universities Quarterly*, directing attention both to the difficulty in recruiting lecturers and to the way the universities are beginning to lose professors and readers to the Government service as well as to industry. With the prospective rise in the number of science students, the position could well become insupportable, nor will it be rectified by adjustments in salary scales alone.

Such considerations were noted in the House of Lords debate. They provide strong argument for the expansion of technological and scientific education in British universities, as Lord Waverley and Lord Chorley urged, both through the greater possibilities of economy in staff and the greater ease with which conditions of service can be offered which attract outstanding men. There is indeed something in Lord Cherwell's contention that if colleges of technology are appropriately staffed and equipped they will have the status of a university and might just as well bear the name; while if they do not offer the conditions which attract sufficient staff of the right calibre they will not fulfil their purpose, whatever they are called.

The real doubt is as to the number of first-class institutions which Britain is able to staff and equip and the proportion they should bear to the institutions training technicians. The importance of this latter factor was repeatedly stressed in the debate; but it was not really met by Lord Home. Lord Weeks put the proportion of supporting technicians which is required for full use to be made of the services of the scientist or technologist as 2 : 1, a figure which was challenged; Lord Waverley inclined to 6 : 1, and Lord Halsbury to 4 : 1. The figure indeed merits some examination in respect of the universities, where senior research workers are notoriously ill-provided with assistance of all kinds. It could well be that a careful scrutiny of the use of man-power by the universities would reveal considerable possibilities of economy, more particularly in regard to the use of graduates or even undergraduates for research projects with little intrinsic importance. By cutting out futile work in this

sphere and providing the experienced investigator with the expert assistance he needs, the output of university research might well be increased while the expenditure of trained man-power was reduced. It was fully recognized in the debate that in the present man-power situation the utmost care must be taken to avoid the waste of skilled man-power and that this applies equally to the Services, government departments, industry and the universities.

Even, however, with a thorough examination of the economic use of scientists and technologists, there will be, as Lord Bennett reminded the House, a great shortage of skilled workers. Britain's need for such man-power depends in part on the skill and efficiency with which it is used, and the extent to which proper equipment as well as the supporting technicians are available. No estimate has been forthcoming as to the magnitude of the demand for technicians, which should in fact take account of the extent to which better use could be made of existing scientists and technologists in many places if the appropriate technicians were provided. The calculation may be difficult and complicated, but some rough estimate should be guiding the overall expansion of technical education if that is not to be seriously diverted from its primary function by the Government's proposals.

Although little reference was made to the Imperial College of Science and Technology in the debate, the expansion of the Imperial College, like Dr. B. V. Bowden's recently published proposals for the development of the Manchester College of Science and Technology, points to the weakness inherent in the Government's policy. The present plan provides for an increase in the number of students at the Imperial College by about 1,500 to a total of about 3,000. An increase of 600 has already been achieved, with an increase of staff from 230 to 300, including 27 new professors and readers. For Manchester, expansion to at least 2,000 full-time students by 1965 is contemplated, and Dr. Bowden indicates at least seven or eight new chairs as desirable in the next two or three years. It has already been announced that the Government proposes to spend £15 million on the expansion of the Imperial College, but although no final figure has as yet been indicated for the proposed developments at Manchester, the University Grants Committee has approved expenditure up to £2 million during the next four years, and Lord Woolton mentioned in the debate a figure of £14·5 million as of the order of what is required to match the opportunity. This indicates the magnitude of the undertaking and what is required to expand existing institutions or create out of them the appropriate institutions for giving the type of education required. It should be obvious that, from the point of view of staff alone, Britain will be hard pressed to find the resources, and the regional distribution must be planned with strict regard to those resources and to the country's needs, and not the desires of particular areas.

Nor can this be done without some re-distribution. Dr. Bowden has directed attention to the difficulty in which the Manchester College of Science and Technology finds itself with regard to non-university work. In the main, if the proposed expansion is to be achieved, the task of training technicians must be transferred elsewhere, and it is in such circumstances that the Government's decision to designate the Salford Technical College as a college of advanced technology is disturbing. It would be hard to sustain a case for two major institutions for technological education in such proximity, and the neglect to pay close attention to the problem of training technicians suggests that even now the Government has failed to see the problem as a whole, or lacks the courage to assert the national interest when it conflicts with local aspirations.

It can at least be said that the Government's proposals, as envisaged by Lord Salisbury and Lord Home, are flexible, and that while greater efforts will be made to induce boys and girls with an aptitude for science to take up a career in science or technology, there is little likelihood that attempts will be made to determine the choice of a career too early. That danger, of which Lord Waverley spoke, is real, and can affect adversely Britain's resources as well as the individual concerned. Some useful suggestions were made in the debate for stimulating a greater interest in science, and these should be followed by the Government as well as by other bodies. The hints as to the importance of looking more closely at use being made in Britain of scientific and technical man-power in all fields are not likely to be lost on the Government, and the Federation of British Industries has already been pressing the point on its members; but both in the technical colleges and in the universities there is room for further inquiry as well as for action. What is still lacking, however, is the concerted overall view of the problem, and the means and authority for co-ordinated action where required to set the target and secure the action that the nation's interest demands. It was for this purpose that Lord Cherwell suggested the constitution of a small committee to examine all these interrelated problems; while the Government persists in its piecemeal approach and fails to deal firmly with points at which national and sectional or local interests conflict, that suggestion deserves strong support.

EDDINGTON

The Life of Arthur Stanley Eddington

By Dr. A. Vibert Douglas. Pp. xiv+208+15 plates. (London and New York: Thomas Nelson and Sons, Ltd., 1956.) 25*s*. net.

IT is no easy task to write a biography of a man of science, especially if the work is to attract both the specialist and the layman. The life of a scholar, centred in his study or laboratory or observatory, is on the surface unspectacular. True, there are great adventures: but they are adventures of the mind, and moreover adventures that are barely intelligible to people whose interests lie in different fields. The biographer therefore faces a difficult problem. Too much attention to historical detail, even if liberally spiced with entertaining anecdotes, will produce a book that seems insipid to the scholar. Too much

insistence on the scientific discoveries will make it forbidding to the layman.

Eddington's life was outwardly uneventful. He was born in 1882. He was still an infant when his father died, and his early years were spent with his mother and sister at Weston-super-Mare. His amazing precocity was apparent even in his boyhood. Before he was sixteen he went to Owens College, Manchester, and in 1902 he went to Cambridge as a Scholar of Trinity. He took the Tripos in his second year, and was Senior Wrangler: never before had this distinction been won by a second-year man. The period from 1906 to 1913 he spent at Greenwich, as chief assistant to the Astronomer Royal. In 1913 he was elected to the Plumian chair at Cambridge, and here he remained until his death in 1944. He was knighted in 1930, and the Order of Merit was conferred on him in 1938. The even tenor of his life was varied by holidays (often in the Lake District with his life-long friend C. J. A. Trimble), excursions abroad to observe eclipses or to attend astronomical congresses, and visits to universities in all parts of the world to lecture on his researches. But if the course of his physical life was comparatively uneventful, his intellectual life was one of high adventure, full of exciting discoveries, and of pioneer voyages "through strange seas of thought alone".

Prof. A. Vibert Douglas, of Queen's University, Kingston, Ontario, the author of this excellent book (which incorporates material contributed by Mr. Trimble), was formerly one of Eddington's research students. The task has clearly been a labour of love. Prof. Douglas has achieved a nice balance between the story of the man and the story of his scientific work. The picture that emerges shows a man rather shy and retiring, but kindly and sympathetic, of immense intellectual power, completely devoted to his research, and with the quiet humour and the fairy-touch of fantasy so evident in his books. The scientific work is described in a way that makes it not too inaccessible to the general reader. Some outstanding points of the story are the early Greenwich work on star-drifts: the impact of Einstein's theory of relativity, of which Eddington was a pioneer exponent: the researches on stellar structure: the exciting moment (in 1920) when the first measurement at Mt. Wilson of the diameter of Betelgeuse verified Eddington's prediction that this star is big enough to hold the Sun and the solar sytem as far out as Mars: the expanding universe: the point at which it became clear that his 'wild idea' about the dwarf stars might after all be possible—that their densities might have incredibly high values, one ton in a cubic inch: the long controversy with Jeans about radiative equilibrium: the final bold speculations about fundamental theory, left still incomplete at his death.

Eddington's life was a peculiarly happy and satisfying one. He had the felicity, denied to many men, of being able to lead just the kind of life he most desired, and to achieve just the kind of things he hoped to achieve. We can justly apply to him Maurice Baring's tribute to a hero in a different sphere:

> "Here is no waste,
> No burning Might-have-been,
> No bitter after-taste,
> None to censure, none to screen,
> Nothing awry, nor anything misspent;
> Only content, content beyond content,
> Which hath not any room for betterment".

L. A. Pars

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Contributions to Prehistoric Archæology

Offered to Professor V. Gordon Childe in Honour of his Sixty-fifth Birthday. By Twenty-seven authors. (Proceedings of the Prehistoric Society for 1955, New Series, Vol. 21.) Edited by Prof. J. G. D. Clark, assisted by Dr. K. P. Oakley and Prof. S. Piggott. Pp. vi+315+30 plates. (Gloucester: The Prehistoric Society, c/o John Bellows, Ltd., Eastgate, 1956.) 42*s*.

THE Proceedings of the Prehistoric Society, New Series, 21, 1955, consist of articles by twenty-seven authors offered to Prof. V. Gordon Childe in honour of his sixty-fifth birthday. There is a characteristic portrait of Gordon Childe as the frontispiece. Prof. Childe is Australian by birth and was at Oxford at the time of the First World War. After going down from the university he travelled widely in Central and Eastern Europe. Later, for a short time, he was the librarian for the Royal Anthropological Institute, but on the founding of the Abercromby chair of archæology at the University of Edinburgh he became its first holder. While at Edinburgh he published extensively on archæological matters and completed some first-class excavations, as, for example, the 'dig' at Skara Brae in Orkney. On leaving Edinburgh he became professor of prehistoric European archæology in the University of London and director of the Institute of Archæology in Regent's Park.

The articles are by a number of distinguished savants, of various nationalities, and the subjects treated range in time from the lower palæolithic to the late Iron Age. It is obviously impossible in a short review even to mention all the various articles, and the citing of one or two does not mean that others are not equally important. Prof. J. G. D. Clark's article on a microlithic industry from the Cambridgeshire Fenland is an important contribution to knowledge, and Dr. D. A. E. Garrod's illustrated article on palæolithic spear-throwers makes interesting reading. Coming to later times, an article by A. Bryusov on neolithic dwellings in the forest zone of the European part of the U.S.S.R., though all too short, is of great interest, as it is not too easy to get information from behind the Iron Curtain. Another interesting article is by T. Sulimirski on Thuringian amphoræ, and J. Banner from Budapest describes the researches on the Hungarian Bronze Age since 1936 and the Bronze Age settlement at Békés-Várdomb. A well-illustrated account of a Bronze Age house at Poliokhni (Lemnos) by Luigi Bernabò Brea of the Syracuse Museum must be mentioned, as, too, must a description of a doctor's grave of the Middle La Tène Period in Bavaria by J. M. de Navarro. The volume concludes with an account of the pins and the chronology of brochs by R. B. K. Stevenson, and a bibliography of Childe's publications compiled by Isobel F. Smith.

The editor is to be congratulated on making this festschrift one of the numbers of the *Proceedings of the Prehistoric Society* and not attempting to publish a separate volume. The existence of the latter would soon be forgotten and in consequence the articles would be comparatively unknown. By consecrating a number of the *Proceedings* the important articles which appear will be accessible and therefore of permanent use to students. M. C. Burkitt

HINDU CHEMISTRY

History of Chemistry in Ancient and Medieval India

Incorporating the History of Hindu Chemistry. By Ácharya Prafulla Chandra Rây. Edited by Prof. P. Rây. Pp. xx+494. (Calcutta: Indian Chemical Society, 1956.) n.p.

THE first detailed history of Indian chemistry was written by the late Sir Praphulla Chandra Rây, professor of chemistry in Presidency College, Calcutta, and the founder of the Indian Chemical Society. It was published in Calcutta in two volumes in 1902 and 1909, and has long been out of print. In his book, Rây gave and translated Sanskrit texts and attempted to set out a connected account of the development of alchemy and chemistry in India from the earliest times. This was an extremely difficult task, since Indian chronology is very defective, the question of dating texts having had little interest for Sanskrit scholars. Rây claimed to have proved that Indian alchemy was, contrary to the view of Berthelot, a national development and independent of Muslim influence. Opinions of scholars still differ on this point, Stapleton, for example, considering that the Indian is a development of Arabic alchemy.

The Council of the Indian Chemical Society decided in 1948 to issue a revised edition of the book, incorporating all additional important material which had since been brought to light, and that its title should be changed to that of the present volume. Prof. Priyandarjan Rây was entrusted with the task of preparing the manuscript and financial assistance was rendered by the Government of India, Unesco, and some Indian chemical firms.

In limiting the work to one volume it was necessary to omit material in the first edition; although some of this is now of less interest, some of it is still of value, and students of the subject will find that the original work is worth consulting. Among the new material added, an account of the archæological discoveries at Mohenjo-daro and Taxila necessarily finds a place. The Sanskrit texts are all retained, since they are of permanent value, and transcriptions in Roman script of some Tibetan texts have been added. The original plates have been included and some new ones added, such as some interesting illustrations of large Indian cannon and of objects from Mohenjo-daro and Taxila. There is a portrait of the original author, who is now called Acharya Prafulla Chandra Rây (1861–1944). The section on the mechanical, physical and chemical theories of the ancient Hindus by B. N. Seal in the second volume of the first edition has been condensed. (Seal dealt with these in greater detail in his book "The Positive Sciences of the Ancient Hindus", London, 1915.) Since there is so much new material in the book, all those who are fortunate enough to have the earlier edition will wish to have the new one.

The problem of the independent development of alchemy and chemistry in India is an extremely difficult one. It will no doubt continue to give rise to conflicting opinions and it may never be satisfactorily solved. The related problem of the Greek and Indian atomic theories, to which more space was given in the first edition, also gives rise to controversy, although informed opinion now seems to consider that they may well have been independent. The early use of mercury in medicine in India seems to be well established by its mention in the Bower manuscript and other early works. The production of zinc in India also seems to have been early. Whether a knowledge of distillation was reached independently or was derived from Greek sources cannot, it seems, yet be decided. Knowledge of the mineral acids was rather late and probably of Arabic origin.

In some cases the volume does not deal with dating so fully as might be wished. On p. 50 the *Arthashastra* is dated in the fourth century B.C., but some of the extracts from it are probably later. Users of the book should not fail to notice the table of dates opposite p. 306, since many of the texts in the body of the work are not dated. Weights are often specified, but no table of equivalents is given for reference.

The foreword by the President and Secretary of the Indian Chemical Society says that, "in spite of all its imperfections, it is hoped that the present volume will be found as useful as its original edition". There can be no doubt that it will, and all those interested in the history of chemistry owe a debt of gratitude to Prof. P. Rây and the Indian Chemical Society for its publication.

J. R. PARTINGTON

THE NEW PETROGENESIS?

L'Évolution de la Lithosphère

Par Prof. Henri Termier et Dr. Geneviève Termier. 1: Pétrogénèse. (Traité de Géologie.) Pp. iv+654+54 plates. (Paris: Masson et Cie., 1956.) Broché, 8,000 francs; Cartonné toile, 8,800 francs.

THIS massive work, following the authors' 1952 volume entitled "Histoire géologique de la Biosphère", is the second of four volumes which together will constitute a "Traité de Géologie". This method of publication has its disadvantages: thus, the third volume, now in the press, is concerned with orogeny, and innumerable unpaged references to it are made in the volume now under review. This becomes exceedingly exasperating, especially as the authors' excellent notion of the *drama*—the succession of events in the evolution of a fold-belt—involves both petrogenesis and orogeny. It is clear that the contribution which the authors' stupendous labours will finally make to their science can only be assessed when the complete work is available.

The authors are more interested in the growing points of petrogenesis than in such static matters as classification or description. While they appreciate the value of abstract discussion or experimental investigation, they rightly stress the fundamental importance of the geological techniques, that is, of field-study and the geological map.

The work begins well. The correlation between the atomic structure of minerals and the processes by which the narrowly conditioned rocks of the crust are evolved is developed. The role of gravity, on both atomic and continental scales, as a motive force in the moulding of the lithosphere is presented. Recent geochemical work is co-ordinated to give an idea of the geochemical evolution of the crust. During this valuable survey, a variety of topics of interest in modern petrogenesis—such as diffusion, silicate classification, radioactive dating, the possibility of a tectonic evolution and many others—are dealt with. Then examples of the *drama* are given, and the sequence of geosynclinal, tectonic, magmatic and plutonic phenomena in the privileged zones of the orogens is displayed. The role of simatic material in the

geosynclines, and the production and arrangement of metamorphic rocks in the fold-belts receive attention.

So far, so good—the petrological geologist of whatever school (and there are many) can obtain great benefit by careful study of the first half of this volume, however much he may differ from the authors in matters of detail. But it is otherwise with what follows, for the authors consider that metasomatism is a factor of the first importance in the formation, and transformation, of rocks. This view colours their treatment of the main classes of both common and uncommon rocks. The operation of fronts, and especially of the basic front, is favoured as the mechanism in metamorphism, migmatization and granitization. By metasomatism, in the wet or in the dry, it is considered that there are produced, for example, skarns, glaucophane-schists, eclogites, charnockites and innumerable other rocks. Metasomatism provides the first term of the Granite Series and, besides, is held to account for many celebrated intrusive bodies. Thus, it is suggested that the Cortlandt complex may be of metasomatic origin, as may also the great Duluth and Sudbury gabbros—the Bushveld body is held to be certainly so. Further, it is proposed that basic and ultrabasic rocks may be the result of metasomatism; the ophiolites may be in part basic fronts to later granites; the alkaline rocks are dominantly metasomatic. All this is strong doctrine, to be evaluated only by the experienced and the expert.

It is possible, indeed likely, that some of these proposed interpretations are correct—but time alone will show. It is a fair comment to say that the authors are rather uncritical where work advocating metasomatism or the operation of fronts, basic or otherwise, is concerned. Their acceptance of a metasomatic origin of the Bushveld complex is a case in point. The book is intended for the expert who must be expected to match it against his experience—he will obtain pleasure and profit in doing this. But, as was said at the beginning of this review, his pleasure and his profit would have been increased had he the third volume "Orogénèse" beside him. Meanwhile, he can be thankful for this lengthy prologue to the full drama.

H. H. Read

SCIENCE AND BRITISH FISHERIES

Sea Fisheries

Their Investigation in the United Kingdom. Edited by *Michael Graham*. Pp. xii+487+12 plates. (London: Edward Arnold (Publishers), Ltd., 1956.) 5 guineas net.

I WAS eager to read this book for two reasons mainly. In the first place, I expected it to provide a much-needed and authoritative presentation of methods and findings that would be helpful generally, but more especially to the student seeking guidance and inspiration in the hitherto unfamiliar field of fisheries investigation. Secondly, because fisheries research is little more than sixty years old, I anticipated that the book would for me amount very largely to a chronicle of the work of personal masters, colleagues and friends at home and in Western Europe, whose distinguished researches and influence had pioneered and developed the science to its present advanced stage.

In both respects the book has made most interesting and stimulating personal reading, and is undoubtedly a treatise of outstanding scientific merit and worth, to be recommended to old and new students alike. It is the composite work of Mr. Michael Graham, director of fisheries research in the Ministry of Agriculture, Fisheries and Food; Dr. C. E. Lucas, director of fisheries research in the Scottish Home Department; Dr. H. A. Cole, Mr. A. C. Simpson and Mr. R. J. H. Beverton, on the scientific staff of the Ministry of Agriculture, Fisheries and Food; Dr. Henry Wood and Mr. R. B. Parrish, deputy director and member of staff respectively of the Marine Laboratory, Aberdeen; and Mr. S. J. Holt, biologist on the staff of the Food and Agriculture Organization of the United Nations. Following a short introduction by the editor, each of the above contributes to form a series of separate essay-chapters, dealing in turn with fisheries of the United Kingdom; plankton and basic production; plankton and fisheries biology; benthos and the shellfish of commerce; the pelagic phase; the cod, haddock and hake; plaice; and the theory of fishing. In a final chapter, the editor gives a synopsis and commentary in review form.

Despite Mr. Graham's recommendation not to do so, I read his synopsis and commentary first, and I am bound to say I was glad I did. For in a little more than eight closely written pages, he succeeds in co-ordinating the subject-matter of the separate essays in a manner that not only reveals the continuity in content, sequence and purpose of the book as a whole, but also provides an impressive and masterly appreciation of the many different kinds of scientific study necessary to a proper understanding and solution of the problems presented by commercial fishing, not excepting the study of the relations between the fisheries and hydrographic conditions, for which, unfortunately, no place for a separate chapter could be found in the present book.

It is a foregone conclusion that this book will rank among those of first importance in standard fisheries literature, and is therefore all the more likely to be recommended to new students of fishery science. Precisely because of this, I feel compelled to criticize Mr. Graham's introductory chapter which, although brief, is nevertheless an introduction—and a powerful one—likely to determine the whole attitude of mind in which the main text will be read. Here, Mr. Graham clearly sets out to press home the very practical and readily acceptable conception of fishery science as "essentially operational research with the aim paramount of elucidating the problems of the commercial fisheries". But in my view, he does so in a way that may well induce any uninitiated reader, at the very outset of his reading, and possibly also of his career, to under-rate, not only the great service of those pioneers who gave us the vast amount of basic knowledge upon which operational research is ultimately dependent, but also the fundamental value of the knowledge itself—knowledge, moreover, that forms an appreciable and inevitable proportion of the main text and its argument. As a constructive suggestion, therefore, I would ask Mr. Graham to consider a re-writing of his introduction in a future edition. For I firmly believe that the objection is valid, and that by dispelling it the value of this already welcome and commendable treatise would be enhanced. Finally, he will, I am sure, share my regret that the purchase price of the book is so high; five guineas is more than many libraries and private students will be able to afford, much as it would be to their advantage to have a copy of their own.

E. Ford

THE AURORA IN MIDDLE AND LOW LATITUDES*

By Prof. SYDNEY CHAPMAN, F.R.S.

THE aurora is one of the many different kinds of atmospheric luminosity. In some of these, light coming from outside the atmosphere is modified by the air or its dust or cloud particles. Rainbows, haloes and the beautiful colours of twilight and dawn are of this type. In a quite different class are luminosities in which light is generated *in* the atmosphere. They include lightning, meteors and the aurora and airglow. Lightning is produced by strong electric discharges associated with thunder-clouds, in the lowest layer of the atmosphere—the troposphere. Meteor light is caused by the entry of small or large pieces of solid matter, with high speed, from outside the atmosphere. The night airglow is produced by chemical reactions in the high atmosphere, energized by sunlight absorbed during the day-time. The aurora is produced by the entry into the atmosphere of positively charged atoms, mainly of hydrogen, together with electrons; they come from the Sun, and enter the atmosphere with speeds far exceeding those of meteors.

The aurora is distinctive in several ways: in colour, form, times of incidence, geographical distribution, and in its many associations with other phenomena, such as sunspots, magnetic storms and ionospheric storms.

Geographical Distribution

The aurora commonly occurs only in high latitudes, and is known as the aurora borealis (or northern lights) or aurora australis (or southern lights). Sometimes the general term aurora polaris (or polar lights) is used. (The name aurora australis has sometimes been given, inadvisably, to auroras in the northern hemisphere, but seen to the south of the observer. The correct use of the term aurora australis seems to have been initiated by Capt. James Cook, in his record of the first aurora reported as seen from the southern hemisphere; it was on February 17, 1773, when he was at lat. 57° 8′ S., long. 80° 59′ E.)

But at times the aurora becomes visible from places far beyond its usual limits. It is seen from middle and low latitudes, sometimes even from the tropics —when it may be called the aurora tropicalis or tropical aurora. These exceptional cases are of outstanding scientific interest. They deserve much more careful study than they have yet received. They also present a rare spectacle of great beauty and mystery to the dwellers in non-polar latitudes.

Auroras and the Geomagnetic Latitude

Many collections of records of auroras have been made. Some have been catalogues of auroras seen from a particular country. The compilation of such a catalogue, especially for a country in middle or low latitude, is a laudable enterprise, worthy of wide emulation. A recent example is the article by S. Matsushita on auroras seen from Japan (*Geophys. Res.*, **61**, June 1956).

Other catalogues have been world-wide. One of the best is that published in 1873 by Prof. H. Fritz, of the Zurich Polytechnic Institute. It covered the period from 503 B.C. to A.D. 1872. Fritz used this great collection of auroral records to construct his well-known map of isochasms*, or lines of equal frequency of auroral visibility; these were revised by Vestine (Fig. 1). This shows, for the northern hemisphere, the expected average frequency of visibility of auroras, per year, at different places along and within the outermost isochasm. The isochasms are oval lines; their centres lie approximately at the northern pole of the geomagnetic axis of the earth, which is 11° from the geographical north pole, and in longitude 69° W. Hence the average frequency of visibility of auroras depends on the geomagnetic rather than on the geographic latitude. This is borne out also by the isochasmic maps later drawn for the southern hemisphere, although these are less complete, because the auroral data for them are much fewer than those available to Fritz. Fig. 2 shows the latest map of the southern isochasms, by Vestine and Snyder. I am indebted to Dr. E. H. Vestine for Figs. 1 and 2.

In each polar region there is a line of maximum auroral frequency; at places along and near this line an aurora is visible on every, or almost every, clear dark night. The frequency of auroral appearance decreases with increasing distance from this line, both to the north and the south.

The outermost isochasm drawn by Fritz coincides approximately with the circle of geomagnetic latitude 33° N.; it corresponds to the appearance of an aurora once in ten years. But it may well be that along this line auroras could be seen more frequently if a careful lookout were kept.

Fig. 3 is a map of the globe (kindly supplied by Mr. D. S. Kimball) with lines of geomagnetic latitude at 15° intervals drawn upon it. It shows places in geomagnetic latitudes less than 45° at which the observation of an aurora has been recorded. The belt between geomagnetic latitudes 45° N. and S. is called the minauroral belt or region, because auroras are rarely seen from it. (The regions or 'caps' above geomagnetic latitude 60° N. and S. are called 'auroral', and the belts between geomagnetic latitudes 60° and 45° N. and S. are called 'subauroral'.) But Fig. 3 shows that auroras have been seen from many places in the minauroral belt—some of them only a few degrees from the geomagnetic equator, and some of them very close to the geographical equator. Places in low geomagnetic latitudes certainly have only a small chance of seeing an aurora, even in a year of sunspot maximum; but the chance, if a careful lookout is kept, may be greater than past records suggest. The chance should be increased if the watch is kept from a point considerably above sea-level, with a clear horizon; for this reason, in low latitudes, airmen have a better chance of seeing auroras than observers at sea-level.

In a given geographic latitude (above 11°), the chances of seeing an aurora are greater the nearer

* Substance of a part of the International Geophysical Year Auroral Manual produced by the Boulder Laboratories of the U.S. National Bureau of Standards as Report No. 5004.

* The word 'isochasm' has reference to the name 'chasmata' (or, in English, 'chasms') used by Aristotle in his "Meteorologica", signifying auroras. The name relates to the *dark* areas of the sky bordered by the auroral light. Aristotle's words suggest that he, a Greek, had seen auroras. This may have been in Greece itself, or, as is perhaps more likely, somewhat farther north, while he was instructing his pupil Alexander the Great at the court of Philip of Macedon.

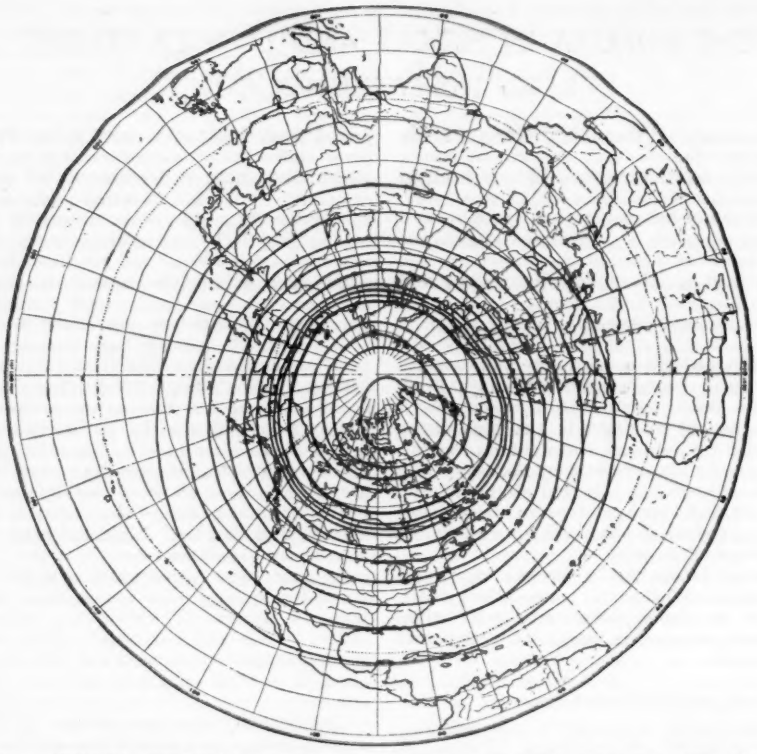

Fig. 1. Estimated percentage-frequency of days with occurrence of aurora, clear, dark nights, high latitudes, northern hemisphere

the place is to the meridian of the geomagnetic pole in the same hemisphere—namely, the meridian 69° W. in the northern hemisphere, and the meridian 111° E. in the southern hemisphere. Hence, for example, Havana in Cuba may expect more auroras than Hong Kong, and Lima in Peru may expect more than Batavia (or Djakarta) in Java.

Outstanding Tropical Auroras

One of the greatest auroras on record occurred on September 1, 1859. Among the places in the tropics from which it was seen was Honolulu (Hawaii). For a few nights both before and after this remarkable event, the aurora was intermittently widespread over the globe, in the subauroral and subtropical belts. The period was one of exceptional activity on the Sun, as indicated by great sunspots and solar flares.

Prof. Elias Loomis, of Yale University, realized the great scientific interest of this rare tropical aurora. He collected, sought and invited all the accounts of it that were available to him. These he embodied in eight memoirs (*Amer. J. Sci.*, volumes for 1860 and 1861). He did not publish any comprehensive study of these records; however, a synoptic study has recently been made by D. S. Kimball, especially with the view of determining the actual geographical location of the aurora at different times.

Another great tropical aurora occurred on Sunday, February 4, 1872. It was seen from Bombay (lat. 19° N.; geomagnetic lat. 10° N.) and from seven other places in India, between geographic latitudes 27° and 36° (or geomagnetic latitudes 19° to 24°). Other tropical places from which it was seen were San Domingo, Guatemala, Aden, the West Indies (Tobago, Scarborough, Plymouth, and Man of War Bay), and, in the southern hemisphere, the islands of Reunion and Mauritius. Many of the descriptions of it are vivid and striking. I have collected all the data I could find for this remarkable event, and hope, in co-operation with Mr. D. S. Kimball, to publish a synoptic study of them.

In 1872 the aurora was accompanied by an outstanding magnetic storm, which for some hours interrupted or disturbed telegraphic cable communications all over the regions of the globe where such facilities then existed.

Auroras in the Twentieth Century

During the present century there have been further outstanding auroras. On September 25, 1909, during an intense magnetic storm, a tropical aurora occurred; it was observed at Singapore (lat. 1° N.; geomag. lat. 10° S.), Batavia (lat. 6° S., long. 106° E.; geomag. lat. 17° S.) and the not far distant Cocos or Keeling Islands (lat. 12° S., long. 97° E.; geomag. lat. 23° S.), and at many other places in higher latitudes, to the north and the south.

On May 13, 1921, a tropical aurora occurred at a somewhat unusual epoch in the sunspot cycle, 3·8 years after the sunspot maximum of 1917·6; an exceptionally great sunspot group was visible at the time. (Of the twelve greatest magnetic storms that occurred in the eighty-one years 1874–1954, three fell approximately four years after sunspot maximum

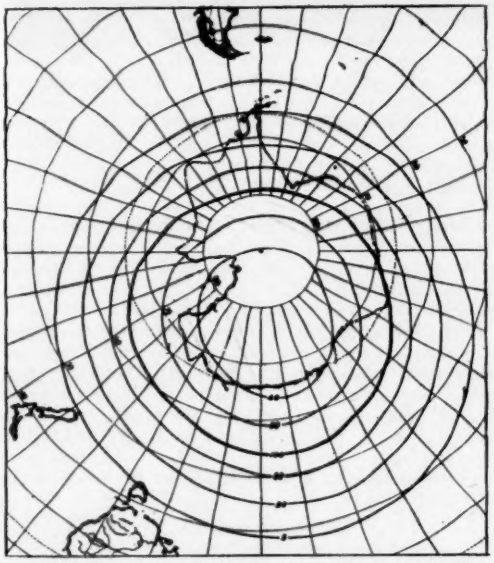

Fig. 2. Isochasms for the southern hemisphere (Vestine and Snyder)

—that of May 1921, and two in 1941, on March 1 and September 18. The great aurora of February 1872 had followed the sunspot maximum of 1870·6 by eighteen months; that of September 1, 1859, occurred less than six months *before* the sunspot maximum of 1860·1.) The 1921 tropical aurora was observed to the south from Samoa (lat. 14° S.; geomag. lat. 16° S.) and from Tongatabu (lat. 21° S.; geomag. lat. 23° S.).

It seems likely that during the present century there have been other tropical auroras, though I have not found records of them. The records of even the great auroras of 1859 and 1872, and of 1909 and 1921, are woefully fragmentary and inadequate, although many may have seen them. Only a very few will have realized that they were seeing a rare but important occurrence, and have thought of making and recording careful accounts of what they saw; and many of these accounts may have been lost or forgotten, or may have appeared in newspapers or other local publications, and not been noticed in scientific journals.

This is not to be wondered at. The aurora came unheralded; it was totally unexpected, and in most cases was seen only by chance. At first its real nature may have been in doubt even for those with some knowledge about auroras. Thus, taken by surprise, they might well be unprepared to make a good record of what they saw, with numerical estimates of elevations and azimuths. There was no widespread awareness of the need to make and collect observations of such phenomena from many regions over the night side of the globe. Loomis was in advance of his time in his serious effort to collect all available data for the great aurora of 1859. I began to collect data for the 1872 aurora only within the past few years. Though interested in magnetic storms since 1916, and although I knew that auroras were associated with them, the record of the 1921 tropical aurora aroused in me no effort to collect observations of it while it was fresh in the minds of its observers; not until 1954 did I make an attempt to seek such information from Tongatabu, but it was too late, and the inquiry was fruitless. Better success, however, attended my efforts to obtain further Indian observations of the 1872 aurora, which Fritz recorded as having been seen from other places in India in addition to Bombay. Through the kindness of Indian friends, some valuable contemporary newspaper accounts of the aurora were unearthed, which had not been reproduced in the scientific journals of the time.

Doubtless there are extant, in official records, newspapers, magazines, ships' logs, diaries and letters,

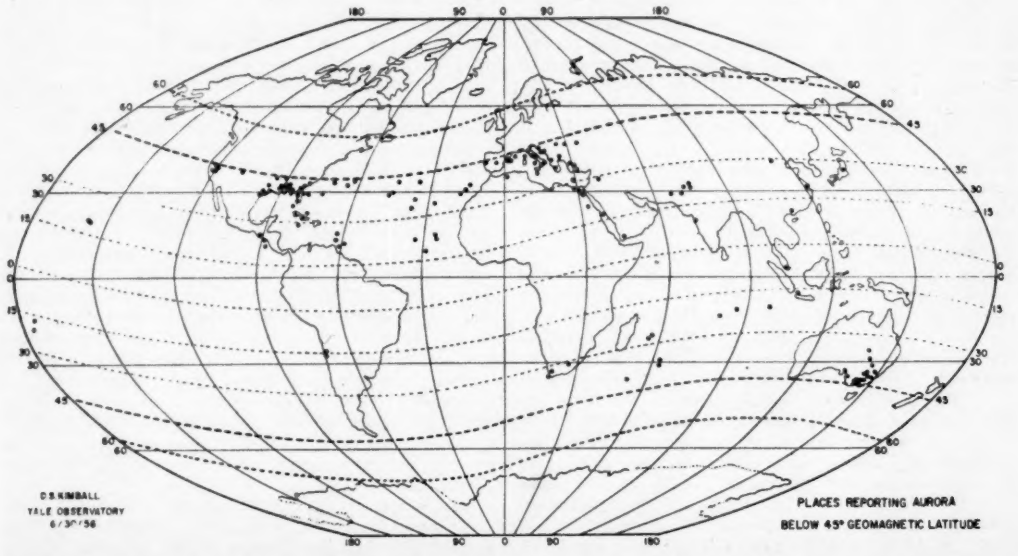

Fig. 3. Map of the globe with lines of geomagnetic latitude at 15° intervals. Dots indicate place below 45° geomag. lat. where auroras have been reported

accounts of other auroral observations that would add usefully to our knowledge. The following list of the twelve greatest magnetic storms recorded at Greenwich during the period 1874–1954 indicates the dates near which it seems most likely to be profitable to seek auroral information, at least in middle and low latitudes. Dates near the 1859 and 1872 auroras should also be considered by searchers of auroral observations not hitherto included in scientific collections.

1882	November 17 and 20	1938	January 25, April 16
1903	October 31	1940	March 24
1909	September 25	1941	March 1, September 18
1921	May 13	1946	March 28, September 21

Even a few gleanings from the past harvest of observations of tropical and subtropical auroras would repay much search, and it is to be hoped that in many countries a search will be made for such observations. In the main, however, one must regretfully face the conclusion that the possible past harvest was never reaped—the knowledge of what was seen was not preserved, it passed away with the generations of men who had the rare fortune to behold these great natural spectacles.

Polar Auroras during the International Geophysical Year

During the International Geophysical Year, 1957–58, the polar auroras that Nature provides will be watched for and recorded, in high latitudes, by many men using varied techniques. Some of the methods will even permit observation of auroras that occur by day, although their light will not be detectable from the ground, owing to the sunlight glare of the skies. There is no doubt whatever that the facts collected regarding polar auroras, during the International Geophysical Year, will greatly increase our knowledge and understanding of these phenomena.

Lower-Latitude Auroras during the International Geophysical Year

The studies of the aurora made in high latitudes during 1957–58 will be seriously incomplete, however, unless adequate information is gained about the auroras that have the greatest intensity, and extend beyond the usual auroral limits. This presents a difficult problem of organization. An aurora, or any particular part of it, is high above the earth, and can be seen from places over a wide area. But it is not sufficient to observe and record it only in one place. To obtain its height and true location in the atmosphere, simultaneous observations are necessary from at least two places. The situation, the form and the intensity all change, sometimes rapidly; good visual descriptions are desirable from many places. Photographs also are helpful, though not essential. The more specific the observations, the better for the study of the aurora. If tropical and subtropical auroras, and also those in higher subauroral latitudes, are to be adequately observed, it is necessary to arouse an interest in them, and willingness to watch for them and record them, among many people distributed all over the globe. This includes not only landsmen, but also seamen and airmen. Observations are especially needed from islands, ships and aircraft in great oceans like the Pacific. The interest must be sufficient to learn what to watch for and record when an aurora appears.

No world-wide effort has hitherto been made to arouse such an interest. For the first time, the International Geophysical Year provides a specially important occasion for such an attempt, because auroral observations then made will be simultaneous with observations of very many other associated phenomena, solar and terrestrial. The International Geophysical Year also for the first time has aroused a world-wide and growing interest in the physical problems of the earth, and provided well-organized channels for co-operative action between the many nations concerned.

In the past, however, there has been a powerful deterrent to willingness to watch for auroras in middle and low latitudes. This is the uncertainty as to when, or even whether, the watch will be rewarded by the appearance of an aurora. Even now it is not possible to predict whether, during the period 1957–58, tropical auroras will occur; the appearance of a subtropical aurora, however, is not unlikely, though the date or dates cannot be foretold. The uncertainty as to the occurrence of an aurora increases the lower the geomagnetic latitude. On the other hand, if an aurora is seen, its interest and rarity are greatest in the lowest latitudes. Those who have the good fortune to observe a tropical aurora may experience the thrill as of:

> "... some watcher of the skies,
> When a new planet swims into his ken."

They can at the same time make a valuable contribution to the world-wide enterprise of the International Geophysical Year, with little or no equipment, and at little or no cost save that of personal effort.

Alerts and Special World Intervals

To make fruitful the willingness to watch for auroras and to record them during the International Geophysical Year, there will be a serious attempt to mitigate the inherent difficulty of the rarity and the past uncertainty in the time of onset of tropical and sub-tropical auroras.

As an essential part of the world-wide plans for the International Geophysical Year, there will be an official World Prediction and Warning Centre of the Comité Spéciale de l'Année Géophysique Internationale (CSAGI, 3 Avenue Circulaire, Uccle, Belgium). This Centre will be at the Ft. Belvoir Radio Forecasting Centre of the National Bureau of Standards, near Washington, D.C. Solar data will be channelled to this Centre: the data will be obtained from a chain of solar observatories girdling the earth, and keeping, so far as practicable, a continuous watch on the varied kinds of activity on the Sun. The Centre will also continually receive magnetic, ionospheric and cosmic-ray data from many parts of the world. It will act in close association with centres elsewhere, which likewise have experience of prediction of geomagnetic and ionospheric conditions, for the benefit of communications networks. The World Centre will from time to time issue warning notices, which will be widely distributed over the globe, by the means found most appropriate and effective in each region. Each National Committee for the International Geophysical Year will be responsible for the distribution of these notices within its own territory, apart from radio broadcasts receivable over this and wider areas.

The warning notices will be of two kinds. The less urgent will announce 'alert' periods: the more urgent will proclaim 'special world intervals' (SWI). Alerts will be announced when the state of the Sun is judged to indicate great and growing activity, of a

kind and intensity more than usually likely to produce auroral, magnetic, ionospheric and other terrestrial manifestations of special importance. If the activity seems likely to render such great terrestrial effects imminent, a 'special world interval' will be proclaimed; if great terrestrial disturbances begin without having been expected, so that no alert has been issued, a 'special world interval' will be proclaimed without delay, and maybe without notice; but ordinarily at least 8 hr. advance notice will be given. The states of 'alert' or 'special world interval' will be terminated at times that will be notified by the World Centre.

The auroral watch will be shorn of some of its value if it is confined to the earlier part of the night. It is hoped that in each country efforts will be made to ensure that a night-long watch will be kept during the 'alerts' and 'special world intervals'. For this purpose it will be of special value to enlist the help of those whose work entails wakefulness from midnight to dawn, but who can, nevertheless, on rare special occasions, devote time to a lookout for auroras, and, if they occur, to a careful watch and record—at least at set intervals (not less often than at each hour).

Reporters for the Aurora

To promote effective observation of the most widespread and intense auroras, world-wide organization is necessary. It is expected that all, or nearly all, National Committees for the International Geophysical Year will appoint their own national auroral reporters. Their function will be to ensure adequate observation and record of any aurora visible from their country or its associated areas; and to collect and forward the records of the observation to a designated Auroral Data Centre.

In the first place, this requires the enlistment of helpers, professional and amateur, prepared to make and record visual auroral observations. The World Meteorological Organization is co-operating by recommending that a number of suitable meteorological observing stations should undertake at least a minimum programme of auroral observation.

The help of the Navy and mercantile marine is also being sought, so that auroral observations may be gained from the great water-covered areas of the globe. Likewise many national airlines are being invited to co-operate by permitting and encouraging auroral observations by their flight staff.

Photographic Observations

Photographs of exceptional auroras can be of great value. They should show the stars also, or include poles, trees or other local objects that will enable the elevation and azimuth of distinctive features of the aurora to be determined.

So far as I know, the lowest geomagnetic latitude from which an auroral photograph has hitherto been published is geomagnetic latitude 36° N. The photograph was taken at a school astronomical observatory on the Greek island of Spetsai (lat. 37·2° N., long. 23·1° E.), by Dr. W. N. Abbott, of the Athens Observatory, in the early morning, not long before dawn (4h. 24m.–4h. 49m. local time: 1h. 55m.–2h. 20m. U.T.). The date was August 18–19, 1950. The aurora was to the east, and already in the sunlight at its high level. The photograph was taken with a telescope, to record the zodiacal light with the constellation Gemini as background. Dr. Abbott thinks it likely that the aurora appeared and was photographed only near the end of his 25-min. exposure. Its image on the plate was unsuspected at the time, and only discovered weeks later, when the plate was developed. The aurora, to the north or east, was in the same geomagnetic latitude as Spetsai, namely 36° N. This is the latitude in which the aurora itself was situated. I have made inquiries to seek out any other observations of this low-latitude aurora, but without success; the hours shortly before dawn are probably those in which an aurora is least likely to be seen. (Dr. Abbott's photograph is published in *J. Atmos. and Terr. Phys.*, **1**, 343; 1951.)

VISUAL DISCRIMINATION OF ORIENTATION AND SHAPE BY THE OCTOPUS

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THE experiments reported here were undertaken in an attempt to discover the mechanism responsible for visual discrimination of orientation and form in octopus. If for any animal we knew enough about the ways in which that animal classifies shapes, it should be possible to formulate hypotheses about the neurological mechanism which performs the classification. This was the approach followed in the classic experiments of Lashley[1] and Fields[2] on rats in the 1930's: their results have never been adequately followed up. The rat is not an ideal animal for such experiments, since in the situation normally used for training rats on form discrimination the rat has been shown frequently to respond in terms of parts of the form only, or in terms of the relationship between the form and the background; it is often difficult to be sure which properties of the forms the rat is using to discriminate between them. This is not true of the octopus in the situation devised by Boycott and Young[3]; *Octopus vulgaris* Lamarck was therefore used in the present series of experiments.

The training situation used is fully described elsewhere[4]. Octopuses were trained individually to discriminate between pairs of shapes: a different group of octopuses was trained on each pair of shapes used. Each member of a pair was presented separately, and octopuses learned to attack one shape (the positive shape) for food reward and not to attack the other shape (the negative shape) in order to avoid an electric shock. The shape which was made positive was changed for the two halves of each group of

Table 1. Performance on Discrimination of Orientation over First Sixty Trials

Asterisks indicate that the difference in level of performance between two adjacent groups is significant at better than the 0·05 level of confidence

Shapes	Dimensions	No. of animals	Per cent correct responses
| vs. —	10 cm. × 2 cm.	6	81
| vs. / or \	,,	8	71*
— vs. / or \	,,	8	65·5
T vs. ⊥	Long stroke, 10 cm. × 2 cm. Tall, 4 cm. × 2 cm.	6	59*
⊢ vs. ⊣	,,	7	56
/ vs. \	10 cm. × 2 cm.	6	50*

animals trained on any given pair. Positive and negative shapes were presented in a randomized order. The scores to be presented here represent the percentage of correct responses a group of animals made to the shapes over a given number of trials. A score of 50 per cent is a chance score and shows that animals were not discriminating between the two shapes of a pair. Higher scores measure the relative ease with which octopuses could discriminate between different pairs of shapes, or the extent to which the classificatory mechanism in the octopus's brain gives a different output for the two members of each pair. In certain cases transfer tests were performed after animals had learned to discriminate between a given pair of shapes; in the transfer tests, further shapes were presented, but octopuses were not rewarded or punished for attacking them. A measure was thus obtained of how far the classifying system treats new shapes as equivalent to the ones on which the animal was originally trained.

The main results for ease of learning different orientations are set out in Table 1. It will be seen that vertical and horizontal rectangles were very readily discriminated, whereas two oblique rectangles were scarcely if at all discriminated. A vertical and oblique, or a horizontal and oblique, could clearly be discriminated; but discrimination was more difficult than for a horizontal and a vertical. In view of the fact that two obliques differ from one another by a 90° rotation, whereas a horizontal or vertical and an oblique differ from one another by only a 45° rotation, this result may well seem surprising. It can only mean that in the classifying system of the octopus vertical and horizontal axes have a peculiar status not shared by oblique axes. The results with *T* figures are a further indication that the octopus can discriminate differences both along the vertical co-ordinate and along the horizontal co-ordinate.

On the basis of these results, the following classificatory mechanism is proposed. The excitation produced by the shapes on the retina is relayed to an array of nerve cells representing a projection of the retina in the optic lobes. The outputs from this array are so arranged that the cells of each column and each row have connexions to further cells specific to each column and row (see Fig. 1). The amount of firing in the output from the cells connected with the columns will now represent the height of the figure, and the amount of firing in the output from the rows will represent the lateral extent of the figure. Such an arrangement of nerve cells is plausible on several grounds. Many of the bodily movements of the octopus are horizontal, and the head is held in a fixed orientation by the statocysts; this means that the same point in the environment will stimulate successively different cells in one row when the

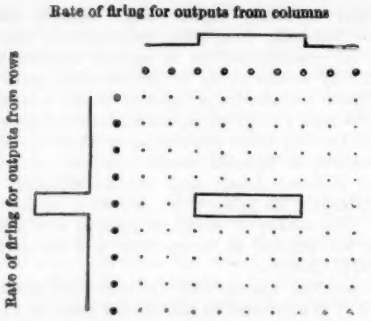

Fig. 1. Dots represent array with horizontal rectangle projected on it. Open circles: cells specific to each column. Filled circles: cells specific to each row. Each cell in the array is connected to the output cell for its own row and the output cell for its own column

octopus is in movement. It is probable that this would result in all cells in any one row developing a common output (cf. Eccles[5], Hebb[6]). When the octopus is stationary, its head movements are usually made in a vertical direction; by a parallel argument this would lead to cells in the same column developing a common output. On this system, discrimination can be performed by comparing two quantities in the nervous system. A further analysing mechanism is needed to analyse and compare the size of outputs from points on rows and columns; such a mechanism presents no difficulty of principle, but for reasons of space no suggestions about it are made here. Because the system works by comparing quantities of excita-

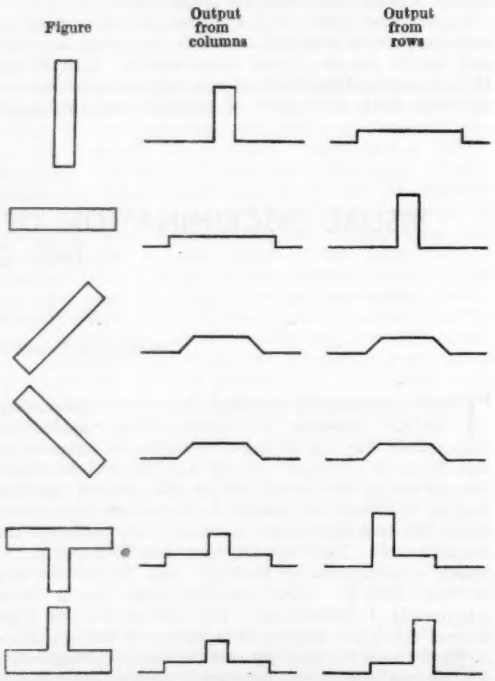

Fig. 2. Figures used for investigating discrimination of orientation, with outputs predicted by theory

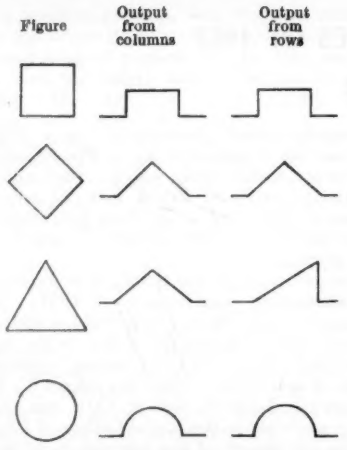

Fig. 3. Figures used in investigation of shape discrimination with outputs predicted by theory

tion, it is unnecessary for the nervous system to store information about absolute quantities when a discrimination is being learned. It also follows that the importance of specific nervous pathways is reduced, and that exact locus of stimulation on the retina is not important in discrimination.

The main confirmation for the existence of a classificatory mechanism of the kind proposed is that it accounts fully for the results reported here and those of other workers in this field. Fig. 2 shows the excitation patterns predicted by the theory in the outputs from rows and columns for the shapes so far discussed. If height of excitation alone is considered, it will be seen that the difficulty the octopus experiences in discriminating the orientations of rectangles used is fully accounted for: vertical versus horizontal produce large differences in output; vertical or horizontal versus oblique produce smaller differences; there is no difference in output between two obliques, hence the confusion between these forms.

The mechanism proposed would produce certain further results on transfer tests. For example, (1) because the proposed system works by comparing quantities of excitation, octopuses should generalize a given discrimination to shapes of different sizes; thus octopuses should treat vertical and horizontal rectangles of different sizes and (within limits) of different ratios between long and short sides as equivalent; (2) having learned to discriminate between a vertical and an oblique, an octopus should treat a horizontal as equivalent to the oblique (the original discrimination depends upon greater excitation in the output from the columns in the vertical than in the oblique, and vice versa for the rows, and horizontal as compared with the vertical produces the same result in an exaggerated form); these predictions were verified in the transfer tests.

The mechanism proposed also accounts for the fact that discrimination of *T* figures is more difficult than vertical versus horizontal discrimination, but easier than discrimination between two obliques. The same operation is involved in the *T* figure discrimination as in the vertical–horizontal discrimination; but in the case of the *T* figures an additional analysing step

Table 2. Performance on Shape Discrimination over Trials 41–120

All shapes were 25 sq. cm. in area. The difference in performance between the first two groups was significant at better than the 0·05 level of confidence

Shapes	No. of animals	Per cent correct responses
□ vs. △ or ▽	4	85
◇ vs. △ or ▽	4	67*
○ vs. △ or ▽	5	67
○ vs. □	5	69
○ vs. ◇	4	74

is necessary in order to discriminate between them; namely, that account must be taken of the direction of the high excitation in relation to the low excitation on the output from either rows or columns (see Fig. 2).

Results of experiments with further pairs of forms are summarized in Table 2. Differences in ease of discrimination are again in accordance with expectations based on the theory (see Fig. 3). Thus a square is more readily discriminated from a triangle than a diamond from a triangle (Table 2); the excitation pattern produced in the outputs from rows and columns is more similar for diamond and triangle than for square and triangle. Again, a square and a circle are as readily discriminated as a triangle and circle, though other theories would predict that this would not be the case[6,7]. Transfer tests again showed excellent generalization to figures of different sizes.

While it is certain that the theory advanced here represents a considerable over-simplification of the mechanism for shape discrimination in the octopus, it is felt that the way it fits with the results described here and with those of Boycott and Young indicates that at the very least a mechanism similar to that proposed is operating. The theory will also account for many of the findings of workers on shape discrimination in the rat, although these are open to the difficulties of interpretation mentioned above. It is worthy of note that Dodwell, on the basis of some recent work (unpublished), concludes that rats also in discriminating visual forms classify them by a system in which vertical and horizontal co-ordinates are of primary importance. It seems probable from the evidence we have that something like the system proposed here may operate in human beings; but in humans it would almost certainly be only one classifying system operating among several others. It is interesting that in humans, in order to bring a point in the environment into the centre of the field of vision, information about the position of that point seems to be divided into the two co-ordinates, horizontal and vertical, in order to give an appropriate output to the eye muscles.

I wish to thank the Royal Society for grants from the Browne Research Fund which made the experimental work possible, Prof. J. Z. Young for invaluable advice and encouragement, and the director and staff of the Stazione Zoologica, Naples, for the hospitality and facilities afforded me there.

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SCIENTIFIC CENTENARIES OF 1957

By JOAN M. EYLES

AFTER the sack of Rome in A.D. 410, and the subsequent decline and fall of the Roman Empire, many of the valuable manuscripts of Greek authors were preserved for the future use of the Western world by passing into the libraries of Islam, whence their contents, after translation and re-translation, were to be returned again to Europe, four or five centuries later.

The scholars who carried out the work of translation included many men learned in science and medicine. One of them was a Syrian named Yuhanna Ibn Masawiah, known in Europe as John Mesue the Elder, who died in A.D. 857. Mesue was medical adviser to Haroun ar-Rashid, and was celebrated for his knowledge of drugs. One of his remedies, known as 'Confectio Mesue', was used throughout the Middle Ages for every variety of heart disease.

Another well-known Arabic writer, the millennium of whose death occurs this year, was Ali Husain Massudi, a geographer and traveller, who is said to have known from personal experience all the countries from Spain to China. His principal geographical work, entitled "Meadows of Gold and Mines of Precious Stones", was translated into French in the nineteenth century.

Two hundred years after the death of Massudi in 957, Neckam, a noteworthy exponent of twelfth-century science, was born. A chronicler has recorded that "in the month of September 1157 there was born to the king at Windsor a sone named Richard and in the same night was born Alexander Neckam at St. Albans, whose mother gave suck to Richard with her right breast and Alexander with her left breast". So Neckam became foster brother to Richard Cœur de Lion. His "De Naturis Rerum", an encyclopædia of scientific knowledge of the time, is interesting as a mirror of medieval science, although containing many fallacies. Neckam was the first English writer to describe the use of the magnet in navigation. He died in 1217.

The sixteenth century was a period of exploration and discovery, and fresh information of the new world found in the west was regularly reaching Europe. The first detailed account of the animals, plants and minerals hitherto unknown to the civilized world came from a Spanish writer, Gonzalo Fernandez de Oviedo (1478–1557). He had been sent to San Domingo in 1514 as supervisor of gold smelting, and his first book on the natural history of the Indies, "Dela naturel hystoria delas Indias", was published in 1526, a much fuller edition in two volumes appearing during 1535–57.

Fernandez de Oviedo was the first to illustrate the pineapple, maize and the prickly pear, all of which had been discovered earlier by Columbus. He died at Valladolid in 1557. Another historian who incidentally mentioned many details of natural history died in the same year. This was Olaus Magnus (1490–1557), Bishop of Upsala, whose "Historia de Gentibus Septentrionalis", published in 1555, described many strange, often incredible, wonders of the northern world.

Another centenary of this period is that of the death of Niccolo of Brescia, an Italian mathematician, better known as Tartaglia. He acquired this nickname, which means 'Stammerer', as a boy, after having had his tongue cut by a French soldier, so that he never spoke freely again. Tartaglia, a self-taught mathematician, found how to solve cubic equations, a discovery which was published by his friend Cardanus, to whom he had imparted it under vows of secrecy.

The tercentenary of the death of William Harvey is an outstanding anniversary of 1957. Born at Folkestone in 1578, Harvey received his education at Canterbury and Cambridge. His wish to study medicine took him in 1597 to Padua, celebrated for its school of anatomy. After his return to England he practised in London, and in 1615 was appointed lecturer in anatomy in the Royal College of Physicians. He taught his theory of the circulation of the blood long before he was persuaded to publish it, in 1628. Harvey was a Royalist and was in attendance on Charles I at the battle of Edgehill. During his prolonged absence from London his house was raided by agents of the Parliament, who destroyed his belongings, including his manuscripts and preparations. Abraham Cowley later wrote of this regrettable event:

> "O cursed war! who can forgive thee this?
> Houses and towns may rise again,
> And ten times easier 'tis,
> To rebuild Paul's than any work of his".

Harvey was buried at Hempstead, near Saffron Walden in Essex.

There have always been in the history of science men whose original ideas received little or no credence for many years, but were later accepted, either partially or in full. Among these is Joachim Jung (1587–1657), a German botanist, who is now recognized as the first to have prepared a scientific terminology for botany. None of Jung's work was published during his lifetime, but one of his manuscripts was brought to England by Samuel Hartlib, and it came to the attention of John Ray. The latter's use and acknowledgment of Jung's morphological principles and terminology were afterwards approved and utilized by Linnæus. Two of Jung's botanical works, published posthumously by different pupils, are now great bibliographical rarities.

It is unusual to encounter a centenarian among men of science, and indeed Bernard le Bovier de Fontenelle, who was born on February 11, 1657, and died on January 9, 1757, failed by a month to achieve his hundredth birthday. Fontenelle, after distinguishing himself in the French literary world, published in 1686 the "Conversations on the Plurality of Worlds", which did much to popularize science in France. He was elected in 1697 to the Paris Academy of Sciences, and served for forty-two years as *secrétaire perpétuel*; in the latter capacity he wrote sixty-nine *éloges* of deceased members. Fontenelle was an admirer of Descartes, whose principles he maintained throughout his life, and indeed he astonished his fellow-countrymen by publishing, when he was ninety-five, an "Apologie des Tourbillons", in support of Descartes.

William Derham (1657–1735), born in the same year as Fontenelle, was one of the many industrious clergymen-naturalists of the early eighteenth century.

He kept weather records, sent frequent communications to the Royal Society (of which he was a Fellow), edited unpublished papers of John Ray and Robert Hooke, and published several works of his own, including "The Artificial Clockmaker", "Physico-Theology" and "Astro-Theology".

Before passing on to bicentenaries of the year, it is appropriate to mention that 1957 is the two hundred and fiftieth anniversary of the births of three men whose names rank high among men of science of the eighteenth century, namely, Linnæus, Buffon and Haller.

Although his name is less well known than those of Linnæus and Buffon, René Antoine Ferchault de Reaumur (1683–1757) was one of the most gifted men of his period. Now chiefly remembered for his thermometric scale, he made contributions to many different branches of science, and his entomological work is still valuable. He did pioneer work on the physiology of digestion, studied artificial incubation, and made important researches into the nature of steel. He was elected a Fellow of the Royal Society in 1738.

Another bicentenary of note is that of the birth of William Charles Wells (1757–1817), born in America of Scottish parentage, but educated at Dumfries and Edinburgh. After graduating in medicine he returned to America, but finally settled in London, where he remained until his death. His "Essay on Dew", published in 1814, was a model of scientific research, and for this work he received the Rumford Medal of the Royal Society, of which he had been elected Fellow in 1793. He also put forward a theory of natural selection that to some extent anticipated Darwin's.

A notable Hungarian chemist of this period was Paul Kitaibel (1757–1817), the independent discoverer of tellurium.

James Sowerby, born March 24, 1757, was primarily an artist, but his association with Sir J. E. Smith, founder of the Linnean Society, in the publication of the famous "English Botany", led him to become an indefatigable collector, first of plants, then of minerals and fossils. He was assisted and succeeded by his sons, so the name of Sowerby has become a familiar one to all naturalists. Sowerby senior died in 1822; his herbarium was purchased by the British Museum in 1859. A year later the Museum acquired also his collection of five thousand fossils.

Engineers will celebrate this year the bicentenary of the birth of Thomas Telford (1757–1834), the self-educated Scots boy who was responsible for so many important engineering works, including the Caledonian Canal, the Menai Bridge, and many roads in the Highlands. Telford, first president of the Institution of Civil Engineers, was buried in Westminster Abbey, a well-merited tribute to his great ability and extensive labours.

Passing now to the names of some well-known men who died in 1857, we come to that of Augustin-Louis Cauchy, the French mathematician, who died on May 23. Cauchy, born in Paris, qualified as an engineer, but later turned to pure science and eventually his researches covered almost the whole field of mathematics. In particular he made important contributions to the theory of elasticity. He became a professor at the École Polytechnique, but on the expulsion of Charles X and accession of Louis Philippe in 1830, Cauchy found himself conscientiously unable to take the oath imposed on office-holders and went into voluntary exile in Switzerland. Later he accepted a chair especially created for him at Turin. Although given an opportunity to return to Paris in 1838, he again refused to take the required oath; but ten years later, when the oath was suspended, he returned to the École Polytechnique. With the establishment of the Second Empire the oath was re-imposed but Cauchy himself was declared exempt, a tribute to his integrity and to the respect he had won.

Two other French scientists who died in 1857 were L. J. Thenard, the chemist, and O. P. A. Dufrenoy, the geologist. Thenard (born in 1777) died in Paris a bare month after Cauchy. He had collaborated with Gay-Lussac during the first decade of the century in the latter's work on the chemical extraction of sodium and potassium. With the same colleague he worked out the first satisfactory method of organic analysis. Dufrenoy, born 1792, visited England in 1823 in company with two young Frenchmen, Elie de Beaumont and Brochant de Villiers, professor of geology in the École des Mines at Paris, in order to study stratigraphy and meet the English geologists familiar with the preparation of geological maps. This was a preliminary to the geological survey of France begun in 1825, which was crowned by the publication, in 1841, of a geological map of France on the scale of 8 miles to the inch[1]. Two years later British appreciation of the work of the French geologists was shown by the award of the Wollaston Medal of the Geological Society of London jointly to Dufrenoy and de Beaumont.

One of the English geologists whom Dufrenoy met was the Rev. William Conybeare (1787–1857), joint author with W. Phillips of the first systematic account of the geology of England and Wales (1822). Conybeare was an enthusiastic geologist, having studied the subject under Kidd at Oxford. He held clerical appointments first in Bristol, and then at Sully, on the Welsh side of the Bristol Channel, and in 1845 became Dean of Llandaff. Conybeare helped to found the Bristol Institution for the Advancement of Science and Art in 1820, and was closely associated with the early work of the British Association, though after 1836 his clerical duties gave him little time for geology.

Another English scientist who died in 1857 was Marshall Hall (b. 1790), a Nottingham physiologist, who invented the term 'reflex action' and published several important papers on reflex functions. A contemporary in a different field was Rear-Admiral Francis Beaufort (1774–1857), whose name is always associated with the wind scale which he was first to prepare; the original scale has of course been modified since it was based on the amount of sail a full-rigged ship could carry.

Others who died in 1857 were J. S. C. Schweigger, a German physicist whose 'multiplier' was designed to increase the sensitivity of a galvanometer, and A. M. Comte, the French philosopher, who is regarded as the founder of positivism.

Among the numerous well-known scientists who were born in 1857 were two who later gained Nobel Prizes in Medicine. The name of one, Ronald Ross, is widely known, for the story of his long and patient attempts to identify the carrier of malarial fever has often been written. His discovery that the anopheles mosquito is the carrier of malaria was announced to the British Medical Association at its meeting in Edinburgh in 1898. Ross became a Fellow of the Royal Society in 1901, and received the Nobel Prize in the following year. He died in 1932, aged seventy-five.

Malaria was for centuries one of the principal impediments in the development of equatorial regions, and Ross's discovery was a major step towards its control and prevention. This same disease, however, was used as a form of treatment for a more serious one by Julius Wagner-Jauregg (1857–1940), in the researches for which he in turn obtained a Nobel Prize. Wagner-Jauregg, an Austrian neurologist and psychiatrist, introduced inoculation with benign tertian malaria as a treatment for general paralysis, and it was for his success in this field that he received the Nobel Prize in 1927.

An outstanding centenary of the present year is that of the birth of Heinrich Rudolf Hertz, the German physicist, who was the first to detect electromagnetic waves in free space and measure their velocity. His experimental confirmation of the predictions of Clerk Maxwell marks an epoch in the history of electrical science. Twelve of his principal scientific papers were published together in 1892, and a year later were translated into English, appearing under the title "Electric Waves". A preface to this book, by Hertz himself, is a valuable account of the development and progress of his scientific work. Another work, his "Principles of Mechanics", was published posthumously and is a classic in the philosophy of science. Hertz died in 1894, when only thirty-seven years of age, and too soon to take part in the great advances which were to result from his work.

Two well-known Irish scientists were born in 1857. One was Joseph Larmor, born in Magherall, County Antrim, on July 11 of that year, who was Lucasian professor of mathematics in Cambridge during 1903–32. His important series of memoirs on electromagnetic theory appeared between 1894 and 1897, and later formed the basis of his book, "Aether and Matter", published in 1900. During 1901–12 Larmor was a secretary of the Royal Society, and in 1921 received a Copley Medal from the Society. He died in 1942.

His countryman, John Joly, born at Holywood, King's County, on November 1, 1857, was professor of geology in Trinity College, Dublin, for thirty-seven years, but his interests were widespread, and lay in the fields of physics and engineering as well as geology. Joly was particularly interested in the question of the age of the Earth, and as early as 1903 pointed out the significance in this connexion of the discovery of continuous heat production by radium. Joly was also interested in colour photography, and his colour transparencies, shown to the Royal Society in 1895, were the earliest of the kind ever exhibited.

Another scientist skilled in photography was the American astronomer Edward Emerson Barnard (1857–1923), born at Nashville, Tennessee. At the age of nine, left fatherless and destitute by the Civil War, he began work in a photographic studio in Nashville. He became interested in astronomy when he was nineteen, and was afterwards able to devote himself to this science, holding posts at several American observatories in succession. It was while he was at Lick in 1891 that he discovered the fifth satellite of Jupiter, and he later discovered four more satellites of this planet. He was a remarkable observer, and did valuable photographic work, photographing comets and sections of the Milky Way. Barnard died in 1923. His countryman and fellow astronomer, James Edward Keeler (1857–1900), born at La Salle, Illinois, carried out astrophysical research of lasting value, particularly in the field of spectroscopy. One of his most interesting spectroscopic demonstrations was that of the particulate nature of Saturn's rings. In 1898 he was appointed director of Lick Observatory, but died two years later.

Elwood Haynes (1857–1925) is another American who should be remembered this year. He discovered several important alloys, including tungsten chrome steel, and in 1919 filed a patent for stainless steel, which he had discovered several years before. Haynes was one of the first Americans to build a horseless carriage, which he drove through Chicago.

The question of the inheritance of acquired characteristics has recently received much attention. An early worker in this field of research was the Danish botanist, W. L. Johannsen (1857–1927). One of the founders of modern research in heredity, he introduced the terms 'pure line', as well as 'gene', 'genotype' and 'phenotype'. He also investigated the effect of certain narcotics upon the resting period of plants, obtaining results which have been made use of by horticulturists.

Among others born in 1857 were three organic chemists who were all distinguished for their researches in the structure and properties of nitrogen compounds. These were Theodor Curtius (died 1928), whose name is associated with the 'Curtius reaction', Arthur Hantzsch (died 1935), who studied the stereochemistry of nitrogen and for many years carried on a controversy about the structure of the diazo- compounds with Eugen Bamberger (1857–1932). The latter carried out many investigations on aromatic compounds. In the United States, the chemist J. J. Abel (1857–1938) was known for his researches on the chemical composition of animal tissues.

There are various instances of men who were trained for the legal profession and later became well known as scientists. One of this group was Karl Pearson (1857–1936), who after being called to the Bar in 1882, turned to mathematics, and in particular to the application of statistical methods to biology, a study initiated by Galton. In 1911, Pearson was elected first Galton professor of eugenics in University College, London; but his best-known book, "The Grammar of Science", was based on the Gresham Lectures he gave in the City of London fifteen years before. Pearson founded *Biometrika* and edited it for more than thirty years.

[1] Eyles, V. A., *Geol. Mag.*, **87**, 373 (1950).

OBITUARIES

Sir Lionel Whitby, C.V.O.

The death on November 24 of Sir Lionel Whitby is a severe loss to the study of medicine and to higher education. Very few men can have equalled him in combining notable scientific research, successful teaching and extensive clinical experience, with great administrative tasks requiring real ability, a capacity for organization, and wide educational interests. Few men can have made themselves so much loved and respected throughout the English-speaking world, since with all his manifold duties he was always ready to give help and advice to students, and to deliver lectures or talks containing much wisdom and common sense as well as information.

Born at Yeovil in 1895, he was educated at Bromsgrove School, whence he gained an entrance scholarship to Downing College, Cambridge, in 1914. But before commencing his university studies he had

attained the rank of major in the Machine Gun Corps, had served in France and the Balkans, had been awarded the Military Cross and had lost a leg. From Cambridge he went to the Middlesex Hospital in London, where he had a brilliant career as a student. After graduation he became assistant pathologist at his Hospital, and at once showed his ability in research and teaching. He afterwards became bacteriologist on the staff of the Middlesex, and, for a period, pathologist at the Hampstead Hospital for Children. In addition to routine bacteriology and pathology, a steady stream of research came from his laboratory. He himself made important contributions to the study of pernicious anæmia and empyema, and in 1936 he began a long investigation on the effect of sulphanilamide derivatives on animals infected with pneumococci. This led to his discovery of the great value of sulphapyridine (M and B 693) in the treatment of pneumonia. But in addition to laboratory work and the preparation of text-books, "Medical Bacteriology" (1928, 6th edit. 1956), "The Nurse's Handbook of Hygiene" (8th edit. 1944), "The Laboratory in Surgical Practice", with Sir Charles Dodds (1931), and "Disorders of the Blood", with Dr. C. J. C. Britton (1935, 7th edit. 1953), he established a wide reputation as a clinical pathologist. He was a member of the group of physicians who attended King George V in his serious illness in 1929.

In spite of being maimed in the First World War, Whitby was a colonel in the Territorial Army in 1939, and he became officer in charge of the Army Blood Transfusion Service with the rank of brigadier. He was responsible for the collection and supply of blood, and also for the training of officers in transfusion. He travelled in the various theatres of war, and he also attended to the health of Sir Winston Churchill. For his services to the reduction of casualties he was knighted in 1945.

In 1945 he accepted an invitation to become regius professor of physic at Cambridge. There he played a very effective, though often difficult, part in the development of postgraduate studies and of research in medicine, linking this development with the work of Addenbrooke's Hospital under the National Health Scheme. He took a keen interest in the health of undergraduates and in the early detection of tuberculosis among them. In 1947 he was elected master of Downing College—a position which brought him much added responsibility but also great pleasure. He was actively interested in all branches of College life, and by encouragement and example he raised the status of Downing to a position it had seldom or never held before. He saw the building of a beautiful new chapel, of new sets of rooms, and the making of other improvements in the College. In 1951 he became vice-chancellor of the University, and for two years filled this exacting office efficiently and successfully. His wide knowledge, his tact and his good humour made him an ideal chairman of the many bodies over which he had to preside; he became the much-loved friend of a great number of people from various faculties and colleges. His wide interests in education led him to consent to serve on the Education Advisory Committee of the Royal Air Force, of which he became chairman.

Whitby's influence on medicine extended far beyond Cambridge. He was president of the British Medical Association in 1948, chairman of the Association's Education Committee, and in 1953 president of the First World Conference on Medical Education. He took an active interest in the World Medical Association. He was widely known in the Dominions and in the United States, which he frequently visited. In 1956 he lectured in Australia and New Zealand as Sims Travelling Professor.

Prizes, medals and honours of all kinds were bestowed upon him by governments, universities and scientific bodies, but these awards made no difference to his friendly and unassuming manner, or to his accessibility to those who wanted his help. Fishing and gardening were his chief pastimes, and he took much interest in the University Botanic Garden at Cambridge. He could not have achieved so much without the help of his able and devoted wife. Lady Whitby herself is a qualified doctor and worked in the blood transfusion service during the War; to her, her daughter and her three sons, the sympathy of friends in many countries will be extended.

H. HAMSHAW THOMAS

Dr. Waldemar B. Kaempffert

THE science editor of the *New York Times*, Waldemar Bernhard Kaempffert, one of the pioneers in science writing in the United States, died on November 27 at the age of seventy-nine. Active as a science editor for fifty years, Dr. Kaempffert served the readership of the *New York Times* for twenty-six years, writing a column of science news and comment that has become a fixture in the Sunday reading of many in America.

He was born in New York City on September 23, 1877, of parents of German descent. After graduation from City College with a bachelor's degree in science in 1897, he became assistant editor of the *Scientific American*, meanwhile studying law at New York University, and was admitted to the Bar as a patent attorney in 1903. Although he did not practice, this training was reflected in his writings, particularly the two-volume work which he edited, "A Popular History of American Invention", published in 1924. He was editor of the *Popular Science Monthly* from 1915 until 1920, and joined the *New York Times* in 1927. A year later he became the first director of the new Museum of Science and Industry at Chicago, returning to the *New York Times* three years later to spend the rest of his life as writer of his weekly column, occasional editorials on science and research, and sometimes covering conventions of scientists in America and abroad.

Dr. Kaempffert was a practising protagonist for the idea that, as he put it, it is important "to present the discoveries of the laboratory so that many will understand". In 1935 he also wrote that "we have passed the stage when gaping wonder can pass for popularization. The facts, simply, humanly and interestingly presented, are what the public wants". He was an effective and distinguished member of the small band of science popularizers who, particularly since the First World War, have made science news and interpretation a valuable part of the world's newspapers. With the respected and dignified vehicle of the *New York Times*, Dr. Kaempffert was able to campaign occasionally for ideas he thought were needed, such as his criticisms of cancer research of several years ago.

Editorially, his own newspaper said of him: "If [he] did not create the profession of science writer, he certainly, over the last half-century, invested it with new standards of ethics, scholarship, dignity

and usefulness". He was a founder of the National Association of Science Writers.

In 1954 Dr. Kaempffert received the Kalinga Prize of 2,800 dollars, having been nominated for the award by the British Association of Science Writers. The same year the *New York Times* received a special award accepted by Dr. Kaempffert from the Albert and Mary Lasker Foundation, and last June he was made a Fellow of the American Society of Mechanical Engineers. The degree of D.Sc. was conferred upon him by the Clarkson Polytechnic Institute in 1939.

Dr. Kaempffert's wife, the former Carolyn Lydia Yeaton, died in 1933.

At services for Dr. Kaempffert at the West End Collegiate Church, the Rev. Dr. Edgar Franklin Romig said: "We call to mind his sensitive awareness of all that life holds—of Nature, with the mystery of its sights, sounds and colours; of art, in its myriad forms and expressions; of music, into whose secrets he entered with creative enthusiasm; and particularly of science, which for him was not only a commanding interest, but a cause to be championed, a means of grace to humanity". Watson Davis

NEWS and VIEWS

New Year Honours List

The following names of scientific men and others associated with scientific work appear in the New Year Honours List:

O.M.: Sir John Cockcroft, director of the Atomic Energy Research Establishment, Harwell.

G.C.V.O.: Sir Harold Hartley.

K.C.M.G.: Sir Stanley Angwin, chairman of the Commonwealth Telecommunications Board, formerly chairman of Cable and Wireless, Ltd.

K.B.E.: Sir Christopher Hinton, member of the board of the U.K. Atomic Energy Authority; Arthur R. Manktelow, deputy secretary, Ministry of Agriculture, Fisheries and Food; Sir Alexander Carr-Saunders, for services as director of the London School of Economics.

D.B.E.: Dr. Janet M. Vaughan (Mrs. Gourlay), principal of Somerville College, Oxford.

Knights: Dr. David S. Anderson, director of the Royal College of Science and Technology, Glasgow; Prof. George L. Brown, Jodrell professor of physiology, University College, London; Josiah Eccles, deputy chairman (operations) of the Central Electricity Authority; Herbert J. G. Griffin, secretary of the Council for the Preservation of Rural England; Prof. Leslie H. Martin, professor of physics, University of Melbourne, defence scientific adviser to the Government of the Commonwealth of Australia; Prof. Mark L. Mitchell, professor of biochemistry and deputy vice-chancellor, University of Adelaide; William L. Owen, director of engineering, Industrial Group, U.K. Atomic Energy Authority; Prof. George W. Paton, vice-chancellor of the University of Melbourne; Dr. Charles P. Snow, commissioner and scientific adviser, Civil Service Commission; James M. Wordie, master of St. John's College, Cambridge, for services to polar exploration.

C.B.: Dr. B. K. Blount, deputy secretary, Department of Scientific and Industrial Research; L. G. Davidson, deputy secretary, Department of Agriculture for Scotland; Sir Henry Beresford-Peirse, Bart., deputy director-general, Forestry Commission; Dr. R. H. Purcell, chief scientific adviser, Home Office.

C.M.G.: R. J. Halsey, assistant engineer-in-chief, General Post Office; R. M. Bere, director and chief warden, Uganda National Park; B. de Bunsen, principal, University College of East Africa, Makerere; G. McM. Roddan, deputy agricultural adviser to the Secretary of State for the Colonies, lately director of agriculture, Kenya; J. T. Saunders, lately principal, University College, Ibadan, Nigeria; Prof. E. W. Titterton, professor of nuclear physics, Australian National University, Canberra.

C.B.E.: B. Ashmole, lately keeper of the Department of Greek and Roman Antiquities, British Museum; A. Barclay, keeper in the Science Museum; P. L. Bazeley, director of the Commonwealth Serum Laboratories, Australia; W. G. Beaton, director of the Inter-African Bureau of Epizootic Diseases, East Africa; Dr. C. M. Cawley, deputy chief scientific officer, Department of Scientific and Industrial Research; Prof. J. K. Charlesworth, emeritus professor of geology in Queen's University, Belfast, for public services in Northern Ireland; Dr. A. T. Green, director of research, British Ceramic Research Association; G. W. L. Harding, lately director of antiquities, Jordan; O. W. Humphreys, director, General Electric Company Research Laboratories; Prof. R. E. Lane, member of the Industrial Health Advisory Committee; P. Lloyd, deputy director (research and development), National Gas Turbine Establishment, Farnborough, Hants; Dr. J. F. Loutit, director of the Radiological Research Unit, Atomic Energy Research Establishment, Harwell; Prof. W. V. Mayneord, professor of physics (applied to medicine), University of London; Colonel R. Meinertzhagen, for services to ornithology; P. K. B. Reynolds, chief inspector of ancient monuments, Ministry of Works; Dr. R. H. Stoy, H.M. Astronomer, Royal Observatory, Cape of Good Hope; D. J. Turner, assistant secretary, Ministry of Fuel and Power; C. H. B. Williams, director of agriculture, Trinidad.

American Society for Applied Spectroscopy Award: Mr. Frank Twyman, F.R.S.

Mr. Frank Twyman has been awarded the Annual Medal of the American Society for Applied Spectroscopy "for his long and devoted service to applied spectroscopy, and in recognition of his profoundly important contributions to instrumentation in this field". In 1898, at the age of twenty-two, Mr. Twyman was engaged by Mr. Otto Hilger, who was carrying on the small, but world-famous, scientific workshop founded by his brother, Adam Hilger. There, in 1908, Mr. Twyman adapted a thermopile and rocksalt optical train to the constant deviation spectrometer and thus produced the first commercially available instrument operating in the infra-red region. During the First World War he took part in the development of the Twyman–Green interferometer, for which he was awarded the John Price Wetherell Medal of the Franklin Institute, and the Duddell Medal of the Physical Society of London. Mr. Twyman was elected to fellowship of the Royal Society in 1924, and he was president of the Society

of Instrument Makers during 1925–26. He is the author of several books on applied optics, one of the best known to spectroscopists being his "Metal Spectroscopy". Mr. Twyman was managing director of Adam Hilger, Ltd., from its incorporation in 1902 until it amalgamated with E. R. Watts, Ltd., in 1946. He retired in 1952.

Vice-Presidents of the Royal Society

THE president of the Royal Society, Sir Cyril Hinshelwood, has appointed the following vice-presidents for the year ending November 30, 1957: Sir David Brunt, physical secretary of the Royal Society, chairman of the Electricity Supply Research Council of the Central Electricity Authority; Sir George Brown, biological secretary of the Royal Society, Jodrell professor of physiology at University College, London; Sir Claude Gibb, chairman and managing director of Messrs. C. A. Parsons and Co., Ltd.; and Sir Bryan Matthews, professor of physiology in the University of Cambridge.

Imperial Chemical Industries Research Fellowships in London

IT is announced by the University of London that Imperial Chemical Industries Research Fellowships have been awarded to the following: Dr. D. A. Haydon, for research on the relation between the zeta potential and surface charge of emulsion drops, in the Chemistry Department at the Imperial College of Science and Technology; A. E. D. Heylen, for research in the field of gas discharge physics, in the Electrical Engineering Department at Queen Mary College; Dr. P. W. Higgs, for research on the theory of quantized fields, in the Physics Department of University College; Dr. W. Segal, for research on the chemistry of natural products, in the Biochemistry Department at the London School of Hygiene; G. R. Wilkinson, for research in infra-red spectroscopy, in the Physics Department at King's College; and E. G. Brown, for research into aspects of microbial metabolism related to the biogenesis and function of heterocyclic ring systems, in the Chemical Pathology Department at University College Hospital Medical School.

Delays in the Patent Office

IN replying to a point raised in the House of Lords by Lord Lucas of Chilworth at the Committee stage on December 6, when the Patents Bill received its third reading, Lord Mancroft said that consultations with industry and professional organizations before the Bill was introduced had indicated solid opposition to giving priority of examination to applicants who desired their patents quickly. This might operate most unfairly and it would be quite impracticable for the Patent Office to distinguish between the applicant who had legitimate reasons for avoiding delay and the one who had not. After going into the matter very carefully, Lord Mancroft said he was satisfied with the position as it is, for while the applicant had to wait, on average, about fifteen months for his patent after he knew the first results of the search conducted in the Patent Office, the length of this period was largely under his control. The sooner he amended his specification to satisfy any objections by the examiner, the sooner the patent was granted. There was little delay in the Patent Office in dealing with amendments to specifications.

United States Federal Support for Higher Education in Science

THE National Science Foundation has recently issued as a National Science Study, under the title of "Federal Support for Science Students in Higher Education, 1954", a survey which shows that in 1954 nearly 390,000 students, or more than one out of every six undergraduates and more than one out of every five graduates, received financial assistance from the Federal Government. Besides these 345,000 undergraduates and nearly 43,000 graduates, well over 1,000 students with doctor's degrees received Federal support for advanced study, research or training, and only 54 of these were in fields other than the sciences. While only 24 per cent of the undergraduates were studying the sciences, including the social sciences, more than 48 per cent of the graduates assisted were in the sciences; and of these, 9·3 per cent were in the biological sciences, 19·7 per cent in the physical sciences, 15·4 per cent in engineering, and 3·9 per cent in the social sciences. At the doctorate level, 88·8 per cent were in the biological sciences (including medicine), 2·6 per cent in the physical sciences, 0·5 per cent in engineering, and 4·0 per cent in the social sciences. Virtually all of the 82,400 undergraduate students in the sciences receiving Federal support were recipients of veterans' educational benefits. Federal payments to undergraduates average about 975 dollars per student: to graduates, nearly 1,200 dollars; and to those receiving postdoctorate training, more than 4,000 dollars, the total Federal expenditure at all three levels exceeding 390 million dollars.

Higher Technical Education in the British Caribbean

THE Secretary of State for the Colonies, Mr. Alan Lennox-Boyd, has, after consultation with the British Caribbean Governments, appointed a mission on higher technical education in the British Caribbean, with the following terms of reference: "To consider proposed developments in the field of higher technical and technological education in the British Caribbean in relation to present and future needs; and, in the light of probable financial resources, to make recommendations". The members of the mission are: Mr. G. S. V. Petter (chairman), educational adviser to the Comptroller for Development and Welfare in the West Indies; Dr. F. J. Harlow, nominated by the Advisory Committee on Colonial Colleges of Art, Science and Technology, who was until recently one of the Secretary of State's educational advisers; and Prof. J. A. L. Matheson, nominated by the Inter-University Council for Higher Education Overseas, who is the Beyer professor of engineering, University of Manchester. The secretary is Mr. J. E. Whitelegg, of the Colonial Office.

Spectrovision

Spectrovision, published by Unicam Instruments, Ltd., Arbury Works, Cambridge, is a new quarterly publication intended to keep its readers informed of developments in spectrophotometry and to act as a medium for the exchange of information concerning new and profitable applications of spectroscopic instruments. The contents will include original contributions from the Research Department of Unicam Instruments, Ltd., and attention will also be directed to published articles, not necessarily connected with the firm's products, of interest to spectroscopists in

general. Bibliographies of noteworthy applications with recommendations as to how these applications may best be carried out using Unicam equipment will be a special feature, and in this connexion the assistance of the newly-constituted Technical Liaison Department will be most valuable. The contents of the first issue of *Spectrovision* consist of an article directing attention to a recent advance in clinical analysis—the determination of uric acid—using an enzyme preparation, "Uricase Leo"; an article entitled "Spectrophotometry", by Prof. N. S. Bayliss (University of Western Australia), which was compiled originally to give students a grounding in the physical principles of absorption spectroscopy, together with an indication of check procedures; two brief articles on accessories; and a small specialized bibliography, consisting of sixteen items, dealing with the determination of iron by colorimetric and spectrophotometric methods.

Probability Theory in the U.S.S.R.

A new journal, *The Theory of Probability and its Applications*, is now being published in Moscow by the Academy of Sciences of the U.S.S.R. under the principal editorship of Prof. A. N. Kolmogorov (available in Britain from Collet's Holdings, Ltd., 44–45 Museum Street, London, W.C.1, £1 5*s*. post paid, for four issues). The first of the quarterly issues for 1956 has now appeared and contains ten long papers and five shorter notes. Eleven of the articles are in the Russian language, with English, French or German summaries, while the remaining four articles are in English, French or German, with Russian summaries. The topics discussed include 'strong' Markov processes and semi-groups of operators (E. B. Dynkin), ordered sets of probability distributions (H. Cramér), sequences of chance events (A. Khintchine), 'Monte Carlo' methods and linear integral equations (V. S. Vladimirov) and stochastic processes the sample functions of which are distributions (K. Urbanik). The journal is handsomely produced and will be much appreciated. The effort made to overcome the language barrier will be welcomed.

Zoological Nomenclature

The International Commission on Zoological Nomenclature gives notice that, as from April 30, 1957, it will start voting on the following cases involving the possible use of its plenary powers for the purposes specified against each entry. Full details of these cases were published on October 31, 1956, in the *Bulletin of Zoological Nomenclature* (12, Pt. 10): (1) *Encrinurus* Emmrich, 1844, and *Odontochile* Hawle and Corda, 1847, designation of type species for; *punctatus* Wahlenberg, 1821 (*Entomostracites*), validation (Class Trilobita); (2) *Cupido* Schrank, 1801, designation of type species for (Class Insecta, Order Lepidoptera); (3) *jurtina* Linnæus, 1758 (*Papilio*), grant of precedence to, over *janira* Linnæus, 1758 (*Papilio*); *Epinephelidi* Tutt, 1896, suppression of (Class Insecta, Order Lepidoptera); (4) *venulosa* Laurentus, 1768 (*Hyla*), determination (Class Amphibia). A proposal is also made for the adoption of the following declaration: determination of the relative precedence to be accorded to two or more names for family-group taxa published in the same book and on the same date. Comments should be sent as soon as possible in duplicate to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

Halley Tercentenary Exhibition

In November Sir Edward Bullard and Mr. C. A. Ronan arranged on behalf of the Royal Society a private exhibition at Burlington House to commemorate the tercentenary of the birth of Edmond Halley (1656–1742). In order to provide facilities for a wider public to see this exhibition, the majority of the material is being displayed during December 31 to January 20 in the Mineral Gallery of the Natural History Museum, London. The Museum is indebted to the Royal Society, Cambridge University Library, National Maritime Museum, Royal Astronomical Society and to the Royal Observatory, Greenwich, which have lent material for the purpose of the present exhibition; as well as to Sir Edward Bullard and Mr. C. A. Ronan for their personal contributions.

International Conference on Scientific Information

The National Science Foundation, the National Academy of Sciences, National Research Council and the American Documentation Institute are jointly to sponsor an International Conference on Scientific Information to discuss the organization and dissemination of scientific information, with special emphasis on storage and retrospective search. The conference will be held in Washington, D.C., early in November 1958. Persons wishing to submit papers for this conference should communicate not later than January 31, 1957, with the Executive Secretary, Dr. A. F. Thomson, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, Washington 25, D.C., indicating the general subject-matter it is proposed to cover.

Conference on Biophysics

A steering committee of some fifty scientists, representing various aspects of biophysical research in the United States, has organized a national biophysics conference to take place in Columbus, Ohio, during March 4–6. The conference will cover studies which employ the approach of physics in biological measurement and theory, at levels of organization from molecules and cells to complex systems and psychophysics. Inquiries should be addressed to Dr. H. P. Schwan, School of Medicine, University of Pennsylvania, Philadelphia 4, Pennsylvania.

Oversea Service Division, Colonial Office

The following appointments have recently been made in the Oversea Service Division, Colonial Office: G. D. Badger (senior agricultural officer, Uganda), assistant director of agriculture (field), Uganda; R. Henderson (agricultural officer, Federation of Malaya), senior agricultural officer (grade B), Federation of Malaya; H. M. James (senior agricultural officer (grade B), Federation of Malaya), senior agricultural officer (grade A), Federation of Malaya; N. Lamont (senior agricultural officer, Fiji), deputy director of agriculture, Fiji; A. S. MacDonald (agricultural officer, Sierra Leone), agricultural officer, Uganda; R. J. M. Swynnerton (deputy director of agriculture, Kenya), director of agriculture, Kenya; W. B. Tevendale (senior geologist, Geological Survey Department, Gold Coast), deputy director of Geological Survey, Geological Survey Department, Gold Coast; W. A. Sands (scientific officer, attached to the Commonwealth Institute of Entomology), scientific officer, West African Inter-Territorial Secretariat; J. L. Taylor (staff surveyor, Kenya), superintendent of surveys, Kenya; M. L. Burdin (veterinary research

officer, Kenya), senior veterinary research officer, Kenya; T. J. Coyle (veterinary officer, Uganda), veterinary research officer, Uganda; R. M. Gambles (senior veterinary research officer, Federation of Nigeria), principal of the Veterinary School, Federation of Nigeria; J. G. Ross (veterinary officer, Uganda), veterinary research officer, Federation of Nigeria; P. M. Rees (senior statistician, Nigeria), deputy Government statistician, Kenya; A. N. C. Thomas, senior agricultural officer, British Honduras; C. T. Bundy, assistant conservator of forests, Nyasaland; R. A. Plumptre, assistant conservator of forests, Uganda; J. G. L. Wardrop, inspector of mines, Mines Department, Gold Coast; K. B. Armstrong, entomologist (West African Institute for Trypanosomiasis Research), Gold Coast; P. H. Giles, scientific officer (entomologist), Northern Nigeria; W. M. Fitzsimmons, veterinary research officer, Nyasaland; A. W. Jukes, veterinary education officer, Veterinary Department, Northern Nigeria; M. W. Smith, veterinary officer, Uganda; P. O. Park, senior scientific officer (chemist), Colonial Insecticides Research Unit, Arusha, Tanganyika.

Announcements

MR. E. GRIFFIN, chief engineer of Metal Sections, Ltd., Oldbury, Birmingham, has been awarded the W. H. A. Robertson Medal for 1956 of the Institute of Metals for a paper on "Cold Roll-Forming and Manipulation of Light-Gauge Sections", which was published in the March 1956 issue of the Institute's *Journal*.

DR. F. R. PAULSEN, of the Atomic Energy Research Establishment, Harwell, and the Windscale Works of the United Kingdom Atomic Energy Authority, has been appointed editor of *Atomics*, published by the Leonard Hill Technical Group.

PROF. CHARLES HOLT SMITH, head of the Department of Instrument Technology at the Royal Military College of Science, Shrivenham, has been seconded for three years from December 31, 1956, to be Dean of the Institute of Armament Studies, Kirkee, Poona 3, India. His studies lie in the field of discontinuous and non-linear servomechanisms. Prof. Kenneth Hayes is to become head of his Department at Shrivenham in his absence.

THE following appointments in the University of Sheffield are announced: Dr. S. Wardle, lecturer in applied mathematics; L. J. C. Hayles, teaching case-worker in the School of Social Studies; C. Baker, honorary tutor in industrial psychology. D. S. Coleman has been appointed to the Steetley Research Fellowship in refractories technology.

AMONG the lectures being given at the Sir John Cass College are a course of ten by Mr. D. G. Arnott on "Radioactivity in Biology and Medicine", to be delivered on Mondays at 6.30 p.m., beginning on January 7. Application for enrolment may be made to the Secretary, Sir John Cass College, Jewry Street, Aldgate, E.C.3.

THE first of a proposed regular series of meetings on nuclear physics to be held under the auspices of the Physical Society will take place at the Atomic Energy Research Establishment, Harwell, on January 16 and 17, 1957, and will be devoted to nuclear physics (including high-energy physics). A list of speakers, titles of papers to be presented, and particulars of accommodation (both for speakers and for the any non-speakers who may wish to attend) may be obtained from the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

A SYMPOSIUM on chemical engineering education, organized by the Institute of Chemical Engineers, is to be held during April 9–11 at the University of Birmingham. Registration of those wishing to attend should be made before March 1. Inquiries should be addressed to the Symposium Manager, Chemical Engineering Department, The University, Edgbaston, Birmingham 15.

THE European Federation for Chemical Engineering is to hold a symposium on "Chemical Reaction Engineering", organized by the Koninklijk Instituut voor Ingenieurs and the Koninklijke Nederlandse Chemische Vereniging, at Amsterdam during May 7–9. Inquiries should be addressed to the secretary, Dr. K. Rietema, 23 Driftweg, Huizen (N.H.), Holland.

AN exhibition of microscopy sponsored by the Quekett Microscopical Club is being held from 2 p.m. to 8 p.m. on January 12 in the Botany Department of the Royal College of Science, Prince Consort Road, South Kensington. Admission is free, and all interested are invited to attend. Subjects covered range from metallurgy and freshwater biology to infra-red and electron microscopy. There will also be a trade section in which the principal manufacturers are represented. Further details may be obtained from the Technical Secretary (Dr. M. V. Salmon), at St. Mary's Hospital, W.2.

AN exhibition of present-day mathematical typography will be held in the lecture hall of Monotype House, 43 Fetter Lane, London, E.C.4, during January 14–26. The exhibition will be opened by Mr. Arthur Phillips, of H.M. Stationery Office, with an address on "Problems of Mathematical Composition", and there will be a paper by the late Mr. C. R. Cosens on "The Typography of Mathematical Tables", and two technical discussions.

THE Atomic Energy Authority has set up a Commercial Department within its Industrial Group, to handle sales of uranium, plutonium, thorium, graphite and other similar materials for the Authority. Within the general policies laid down by the Authority, this Department will be responsible for negotiating terms and conditions of sale, including the determination of selling prices. The manager of this Department is Mr. W. P. Warren, whose address is: U.K. Atomic Energy Authority, Industrial Group Headquarters, Risley, Nr. Warrington, Lancs. Radioisotopes, stable isotopes and special requirements for small quantities of research materials will continue to be handled by the Research Group of the Atomic Energy Authority.

UNDER the provisions of the Fulbright Programme, travel grants are available to citizens of the United Kingdom and British Colonies to go to the United States for an academic or educational purpose, provided that they have the financial support in dollars for the visit, and have been accepted by an American institution of higher learning. The grants cover the cost of direct travel between the candidate's home and America and return, and are available during June 1, 1957–April 1, 1958. Applications must be submitted by March 15, 1957 (for those travelling between June 1 and July 31), or by June 1 (for those travelling after August 1). Application forms and further information can be obtained from the United States Educational Commission in the United Kingdom, 71 South Audley Street, London, W.1.

THE COLLEGE OF TECHNOLOGY, HULL

NEW WORKSHOPS AND LABORATORIES

WITH the official opening on December 3, 1956, of the first phase of the new College of Technology by Lord Hives, chairman of Rolls-Royce, Ltd., and chairman of the National Council for Technological Awards, commenced a new era of greater activity and opportunity in the field of technical and technological education for the City of Kingston upon Hull.

Since its inception in 1894 the College has identified itself with the industrial and commercial life of the City and grown to become the seat of centralized technological studies in the area and beyond, until in 1956 there were 530 full-time and more than 3,800 part-time day and evening students. The increasing numbers of students could only be accommodated by the acquisition of a number of annexes scattered about the City, and to overcome the problems inherent in such decentralization the Education Authority produced its plan of central Colleges for Technology, Commerce and Art and an Adult College for Liberal Studies to be sited in the Queen's Gardens area and which "with their garden precincts were to contribute to the architectural beauty which the planners contemplated for the centre of the City".

The first stage of the College of Technology is the spacious single-story workshop block now completed at a cost of about £312,000 and containing additional new equipment and furnishings worth £127,000. It accommodates the Mechanical Engineering, Electrical Engineering and Building Departments. It also contains temporary classrooms and drawing offices, which will be later transferred to the main block, the vacated space being used for the further extensions of these Departments and the Printing Department of the College.

The building is arranged as four blocks of accommodation divided by wide access and service corridors and with a floor area of approximately 64,000 sq. ft. It is planned on a 24-ft. square grid and the structure is entirely in reinforced concrete. The building is carried on *in situ* piles and from the pile caps ground beams carry the superstructure and also form the system of under-floor service ducts which serve all workshops. Large crawlway ducts beneath the corridors accommodate the main service pipes, and from these smaller ducts branch off to each shop. The workshops are lit by a large north light and a small south light which balances the lighting intensity. Artificial lighting is by fluorescent fittings. The building is faced externally with hand-made facing bricks and with reconstructed Portland stone slabs. The heating installation consists of unit heaters supplemented by radiators fed by a low-pressure hot-water system.

The three Departments offer a wide range of courses. Thus the Mechanical Engineering Department provides full and part-time courses in mechanical, aeronautical, production, marine, civil and automobile engineering and naval architecture for the ordinary and higher national certificates and diplomas, University of London degrees and postgraduate work. In addition, there are courses for technicians and craftsmen in the engineering and allied industries. Up-to-date machinery and equipment have been installed throughout. The Heat Engines Laboratory contains an oil-fired water-tube boiler with superheater and a comprehensive range of prime movers, including a 30 b.h.p. steam turbine and condensing plant, a Ricardo variable-compression engine, a single-cylinder diesel engine and a Rover gas turbine. The services of the Materials Test Laboratory with its wide range of testing machines are extensively used by local engineering firms, while the Metrology Laboratory is well equipped with precision measuring machines and instruments. A Structures Laboratory, equipped for advanced work in civil and aeronautical engineering, has a reinforced floor for dealing with heavy loads. Two large Aeronautical Laboratories with a supersonic bay contain a variety of wind tunnels, together with an air compressor and receivers having a working pressure of 350 lb. per sq. in. for operating the supersonic wind tunnel, now being designed, and to be constructed, by the staff. In addition to two well-equipped Mechanics Laboratories, there is a Hydraulics Laboratory with a specially constructed flume and containing experimental turbines and pumps fitted with dynamometers. The Machine Shop contains more than twenty modern machines representative of a very extensive range of operations in engineering practice, and the Production Engineering Laboratory includes a vertical gear generator, a relieving lathe, a superfinishing machine and a 17-in. lathe with hydraulic profiling equipment. Two Automobile Engineering Shops, a large Fitting Shop, separate Acetylene and Electrical Welding Shops with argon-arc equipment and a maintenance workshop complete this section.

The Department of Electrical Engineering provides courses for the national certificates and London external degree, certificates of competency in marine and civil aviation radio engineering and radar. City and Guilds courses associated with electrical and communications engineering for technicians are also offered.

The laboratories possess many distinctive features in lay-out and equipment. There are two Science Laboratories, an Electrical Machines and an Advanced Circuits Laboratory with such special items of equipment as a grid-controlled six-phase mercury arc rectifier, motor alternator sets with wide frequency ranges, a high-tension testing transformer and an a.c. potentiometer with all associated accessories. An Electronics and Telecommunications Laboratory is equipped for instruction at all stages and the radio equipment and morse rooms are provided with the latest marine transmitting, receiving, direction-finding and echo-sounding gear. There is also an Electrical Installation and Cables Laboratory and photometer room.

The Building Department provides full-time and part-time courses in general building, civil engineering, quantity surveying, sanitary inspection, timber technology, etc., leading to professional qualifications. Building craft courses are conducted in carpentry and joinery, brickwork, masonry, plumbing, and woodcutting machinist's work.

A spacious carpentry and joinery workshop with portable electric hand-tools is adjacent to the wood-cutting machine shop, which includes such modern high-speed machines as a four-cutter, a spindle moulder, a router and a morticer.

The workshop block will be connected with the main entrance hall and exhibition space of the nine-tiered main building, on which work is commencing now, at a cost of about £675,000. This second instalment will include administrative offices, suites of class-rooms, drawing offices and lecture theatres, staff and students' libraries, laboratories for pure and applied chemistry, chemical engineering, physics (including special laboratories for work on radioisotopes), the natural sciences, mathematics (statistics), the building sciences, radar and food technology.

Staff and students' refectories and students' common rooms will also be available.

The principal of the College, Mr. Emlyn Jones, has a staff of 64 full-time and 350 part-time lecturers and was, at one time, the head of the Chemistry Department at the Rutherford College of Technology, Newcastle upon Tyne.

INSTRUMENTATION APPRECIATION IN CHEMICAL INDUSTRY

TO increase the efficiency of its factories, both large and small, must be the constant aim of every section of British industry, and any new steps which are taken towards this end are a matter of general importance and interest. This is perhaps particularly true of the chemical industry, which makes such a large contribution to our total exports and the products of which are so widely used as the basic materials of other industries.

Instrumentation, which is taken to embrace both the equipment and the technique used for measurement and automatic control, is one of the most powerful aids which the industry has had at its disposal in increasingly better developed form and which it has used increasingly effectively for thirty years and more. It is to be expected, in Britain as in other countries, that the extent of the use of instrumentation and the skill with which it is applied will have varied very much in all industries from one factory to another. In some instances, this variation, in the past, has followed the differences in the conditions demanded by the operational needs of the processes and, particularly, according to the uses of continuous or batch methods of production. More recently, however, the limitation to the use of instrumentation by industry has been set either by the age of the factory or by an unawareness on the part of the factory management of the benefits to be derived from proper use of instrumentation.

One or other of these two limitations has been responsible for a very marked disparity between the best and the worst practice encountered in the chemical industry in Britain. This of course applies, to a greater or lesser extent, to the use which the industry has made of other means of decreasing its production costs and of increasing its output; it is not a condition peculiar to the chemical industry, nor does the worst practice in the chemical industry compare unfavourably with the worst in other industries in Britain or in other countries, even the most progressive of them, any more than does the best practice to be found in Britain fall short of the best to be found elsewhere.

It is none the less important that every possible step should be taken to encourage the chemical industry, as well as all other industries, to make the fullest use of instrumentation as an aid to production efficiency in all its factories however small some of them may be. The Association of British Chemical Manufacturers recognized the need for doing everything possible to bring the standard of instrumentation of the less well-instrumented factories up to that found in the most progressive organizations, and the Association set up an Instrumentation Advisory Committee to assist in doing this. The task is not an easy one, for several reasons. Perhaps the most important of these arises from the fact that the firms which are backward in this field and which, therefore, need most help are in this position because the value of instrumentation is not appreciated by their managements. Consequently, they have not realized that they can obtain help from the Instrument Advisory Committee and, therefore, they do not seek it.

The logical action on the part of the Association's Advisory Committee was to arrange an "Instrumentation Appreciation Conference" designed especially for managers, which was held in Harrogate during April 19–22, 1956. Great care was taken in the selection of subjects for discussion and in their presentation. Naturally, emphasis was placed on the profit to be obtained from good instrumentation. The Committee was fortunate in being able to present a greater number of concrete examples of applications where such profits had been obtained than has been presented at any other conference on this subject. Moreover, these examples were chosen to show how even very simple installations for measurement and control could bring substantial benefits. As was inevitable, in spite of the care taken to point out the general nature of the conference, many firms sent technical representatives instead of the managerial representatives. Nevertheless, a number of firms responded to the recommendations of their Association, and the formal, and particularly the informal, discussions during the conference showed that it fulfilled a very valuable purpose.

The proceedings have now been published*, complete with the papers and discussions, and with a report on the final session during which members of the Advisory Committee answered questions from the delegates. It is hoped that many of those in the chemical industry who were not at the conference and who are responsible for the management of factories will read these proceedings very carefully. Their attention should be directed to the introductory paper by Mr. Bertram White, managing director of A. Boake Roberts and Co., Ltd., and chairman of the Federation of British Industries' Technical Legislation Committee, and to the concluding paper on the reasons for instrumentation, by Dr. Hiscock, operations director of the Imperial Smelting Corporation, Ltd., and chairman of the Association of Chemical and Allied Employers. These two papers make stimulating reading and are indicative of the spirit of the whole conference and of the object which the authors of the papers set out to achieve.

* Proceedings of the Instrumentation Appreciation Conference, Hotel Majestic, Harrogate, 19th to 22nd April, 1956. Pp. vi+183. (London: Association of British Chemical Manufacturers, 1956.) 12s. 6d.

That this objective was regarded as extremely important by the Association of British Chemical Manufacturers was made doubly clear by the unique offer made on behalf of the Instrument Advisory Committee by its chairman during his summing-up of the conference. This invited members of the conference to submit to the Advisory Committee an example of an actual working plant in order to obtain the Committee's recommendations on its instrumentation. The only condition attached to this offer was that, if the firm concerned implemented the recommendations, the results of it doing so should be published as an example of the technical and economic results which can follow the installation of improved instrumentation.

It will be very interesting to see the results of such a co-operative effort, which it must be anticipated will stimulate that appreciation of instrumentation by management which it was the object of the Conference to foster. Meanwhile, those who are responsible for factory management, and who were not able to be at the conference, should read the proceedings now published, with the view of applying some of the recommendations arising from the papers and discussions.

DEVELOPMENTS IN OPTICS AND MICROWAVES

THE ever-increasing rate of scientific progress makes it difficult for research workers to keep abreast of developments within their immediate field of interest let alone those in related fields. With this consideration in mind, the Antennæ and Propagation Group of the Institute of Radio Engineers and the Optical Society of America held a joint symposium on microwaves and optics at the Lisner Auditorium of George Washington University during November 14–16. This was attended by some four hundred workers representing a wide range of interests in optics and microwaves and provided an excellent opportunity of comparing the present state of development in the two subjects. The first session was devoted to survey papers on microwaves (J. Brown, University College, London), infra-red (J. A. Sanderson, Naval Research Laboratory, Washington), modern optical systems (A. Bouwers, N.V. Optische Industrie, Delft) and electron optics (L. L. Marton, National Bureau of Standards, Washington), and these served as a general background against which later more specialized papers could be appreciated.

Theoretical diffraction studies are of considerable importance to both microwave aerial and optical lens design, and an excellent account of current work was given by Prof. M. Kline and Dr. B. Keller, both of New York University. Both papers concentrated on the development of the theory in physical terms, Prof. Kline developing an asymptotic series solution beginning with the geometrical optics term, and Dr. Keller making extensive use of ray ideas. Such methods appeal to experimenters in that the significance of the various mathematical terms is evident physically. A historical account of the study of diffraction by a sphere (N. A. Logan, Air Force Cambridge Research Center) illustrated the widespread interest in using the work carried out in the late nineteenth and early twentieth centuries: a notable feature of the symposium as a whole was the awareness of how much the subject developed around the turn of the century.

Two papers on the optics of the eye, one by J. M. Enoch, of Ohio State University, on the nature of the receptors, and the other by H. A. Knoll, of the University of California, brought out many points of common interest. The receptors are similar in general form to microwave dielectric rod aerials, and scale-model experiments carried out at centimetric wavelengths are providing useful information on the behaviour of these receptors. A complicating factor in the lens system of the eye is the variation of refractive index throughout its volume. Such non-homogeneous lenses are now well established at microwave frequencies and their potentialities were described by K. S. Kelleher, of Melpar, Inc. There is a fruitful field here for further co-operation between those using optics and microwaves. The use of microwaves in interferometry, with possible applications to metrology, was discussed by W. Culshaw (National Bureau of Standards), and diffraction studies on microwave lens images were described by G. Bekefi and G. W. Farnell (McGill University). The relative ease with which both amplitude and phase can be measured at centimetric wave-lengths makes microwaves a powerful aid in further diffraction studies.

A full session was devoted to the implications of information theory to optical design. O. H. Schade (R.C.A.) described the elegant methods by which he has designed lens systems using communication theory, and A. Marechal (Institute of Optics, Paris) demonstrated the improvement in imaging which can result from optical filters operating on the amplitude and phase of the transmitted light. A general paper on the application of communication theory to optics by F. D. Smith (Boston University) led to a stimulating discussion: optical workers inclined to the view that communication theory would lead to no new significant results, one speaker remarking that the Fourier transform had been widely used before the introduction of information theory. On the other hand, it was evident that those whose interests lay in the communications field felt that the use of communication terminology and methods greatly facilitated their understanding of optical results.

F. T. Haddock (University of Michigan) surveyed the development of radio astronomy, and W. H. Bennet (Naval Research Laboratory) demonstrated the use of a new kind of valve which can be employed for studying the behaviour of proton streams under the action of magnetic fields. This was illustrated by an excellent film, and the results are being used to account for the properties of the aurora. The effects of the atmosphere on radio waves (M. Katzin, Electromagnetic Research Corporation) and on optics (W. E. Middleton, N.R.C., Canada) were shown to be similar in many respects. Duct propagation is an added complication in the microwave region; but apart from this the behaviour was seen to follow the same general trend in both cases.

The final session, to which F. J. Tischer (Ohio State University), K. Henize (Smithsonian Institution) and L. M. Hartman (G.E.C.) contributed, was devoted to problems arising in connexion with the observation of, and communication to, earth satellites and rockets. It appears that much information is still needed on the behaviour of electromagnetic waves through hypersonic shock layers associated with missile flights.

A symposium of this kind is very valuable in that it directs attention to problems arising from a wide range of studies and in providing a meeting ground for people of very diverse interests. The Washington symposium was successful in both ways and is likely to lead to some interesting new work in the region common to optics and microwaves. J. BROWN

THE MEANING AND REACTIONS OF COMPLEMENT

BY definition, complement is a hypothetical substance present in fresh serum that has the property of causing the escape of hæmoglobin from red blood cells that have combined with antibody. There are, however, also a number of other reactions for which complement or substances resembling complement are essential; these other reactions were the chief subjects discussed in the symposium on "Complement" at the first meeting of the newly formed British Society for Immunology during November 9–10.

As Prof. J. R. Marrack pointed out in his introduction to that symposium, the first and second components of complement can be separated in mid- and end-piece, and the third component can be obtained free from other components; but the fourth component has not been prepared free from other components and may well be an active group of the first and/or second component.

Bordet[1] wrote of 'fixation' of complement and the expression is established by long usage. But all that is observed when complement is 'fixed' by antigen–antibody complexes is that complement activity is lost. It seems that the only evidence that the active substance actually combines is found in experiments that Dean[2] published in 1912. He found that an antigen–antibody precipitate, formed in the presence of mid-piece in the cold, washed and resuspended, had mid-piece activity. Otherwise the only evidence that any component of complement is fixed are the facts, first shown by Heidelberger[3] in 1941, that a complement-fixing antigen–antibody system forms more precipitate in the presence of fresh serum than in inactivated serum; and that this difference is not found when the antigen–antibody system is one, such as pneumococcal polysaccharide and horse antiserum, that does not fix complement. Mr. R. G. S. Johns presented a diagram showing this increase in precipitate over a wide range of ratios of antigen (ovalbumin) to antibody in the presence of fresh human serum; in the presence of heat-inactivated serum the amounts of precipitate were almost identical with those of the saline controls. With horse serum as the source of complement the matter was less simple; for over a wide range of antigen/antibody ratios the amount of precipitate formed in the presence of heat-inactivated horse serum was less than that formed in saline. This recalls the demonstration by Maurer and Talmage[4], using antigen and antibody labelled with iodine-131, that the amounts of antigen and antibody precipitated differed in the absence or presence of complement.

Heidelberger has shown that most of the protein taken up from fresh serum by an antigen–antibody precipitate comes from the fraction containing the first component. Mr. Johns could find no evidence that the second and fourth components added anything to the precipitate; they may therefore be inactivated and not actually fixed. The extra protein derived from fresh serum is not merely entrapped when the antigen–antibody precipitate is formed, for Mr. Johns found that a pre-formed precipitate, resuspended with fresh serum, will eventually take up as much protein as would have been added if the precipitate had been formed in the presence of the fresh serum.

The work of Levine, Mayer and colleagues[5] has demonstrated three stages in the interaction of complement with sensitized red-blood cells. In the first stage, which requires calcium ions, the first and fourth components are involved; in the second, which requires magnesium ions but not calcium ions, the second component is involved; in the third stage, which is very slow at temperatures below 17°, the third component effects a change in the red cells, the result of which is the escape of hæmoglobin. The product (*a*) of the first stage and that (*b*) of the second stage are unstable; at 37° they are inactivated—that is, they undergo such a change that the further stages no longer take place on addition of the appropriate components. The inactivation of *b* is rapid, so that the eventual degree of lysis depends on a race between this inactivation and the action of the third component. Furthermore, Levine[6] has found that after treatment of *a* with *iso*propylfluorophosphate, which is regarded as a specific inhibitor of esterases, hæmolysis does not occur on addition of second and third components. Treatment of serum that contains complement—that is, treatment of complement that has not been fixed—does not inactivate the complement. Also, Becker[7] finds that product *b* (or its inactivated form) hydrolyses tosylarginine methyl ester, whereas neither the serum from which the complement is derived nor red blood cells without complement hydrolyse this substrate. We have, therefore, a method of demonstrating a change in complement after 'fixation', apart from the hæmolysis of red blood cells. It would be interesting to know whether an esterase is either formed or becomes activated when complement is fixed by simple antigen–antibody precipitates.

We have further evidence of a change in complement on fixation in the conglutinin reaction. Bordet and Streng[8] found that bovine serum agglutinated sensitized red blood-cells and other antigen–antibody complexes that had fixed complement (particularly horse complement); they called this reaction conglutination and postulated a substance, conglutinin, in the bovine serum. Unfortunately, much confusion has been caused by the application of the name 'conglutination' to other reactions in which complement is not involved; but at this symposium the word was used in the correct sense. Streng[8] and Wartiovara[10] have shown that though normal rabbit serum contains little conglutinin, something very similar to it appears in the serum of rabbits after intravenous injection of antigen–antibody complexes that have fixed complement; this conglutinin-like substance, which appears to be an antibody against fixed complement, they called immunoconglutinin; it is permissible to suppose that the natural conglutinin is also an antibody against fixed complement. Wartiovara[10] and Coombs and Coombs[11] found that this conglutinin-like substance was also formed after bacteria alone, without antibody, were injected, and considered that this immunoconglutinin was antibody against the rabbit's own complement fixed on

the bacteria after these had combined with antibacterial antibody formed by the rabbit. Coombs and Coombs suggested that complement was so changed, when fixed, that it became a foreign protein and stimulated production of antibodies in the rabbit. Since first, second and fourth components are needed to render sensitized red blood cells agglutinable by conglutinin, and since the sensitized-red-cell–complement complex is agglutinable after incubation at 37°, it appears that conglutinin reacts with the complex in the inactivated *b*-stage.

In the symposium Drs. R. R. A. Coombs and J. Marks described an extensive investigation into the conglutinin levels in the sera of human beings. Normally the conglutinin titre is low; but in infectious diseases the titre rises and reaches a maximum at a time when antibodies against the infective agent should have appeared in the circulation. Among normal people the titres were lowest in those months in which infectious diseases are least common. It may be inferred that human beings also make antibody against their own complement which is fixed by an antigen–antibody complex. In the discussion it was suggested that the large amount of conglutinin in the sera of ruminants is due to the high bacterial content of the stomach.

Properdin was originally recognized by its ability to combine with zymosan to form a complex that inactivates the third component of complement at temperatures above 17°. The other components of complement and magnesium ions are required for the formation of this complex[12]. Purified properdin can be eluted from the complex and properdin-free serum can be prepared by adsorption with zymosan at 17°. It was later found that properdin is instrumental in killing certain bacteria. Dr. A. C. Wardlaw presented tables showing that the components of complement and magnesium ions are required for this bactericidal action as well. He also reported that the percentage of bacteria killed in a given time is independent of the number of bacteria. This may be interpreted as evidence that an enzyme action is involved; but, as pointed out in the discussion, it may be due to differences in resistance of the bacteria.

Dr. J. V. Dacie found that complement is necessary for firm combination of cold-agglutinin with red blood cells. It appears that cold-agglutinin is not a γ-globulin, as agglutination by a supposed anti-γ-globulin serum of cells that have combined with cold-agglutinin is not inhibited by γ-globulin; it may be an α- or β-globulin.

Reduction of complement in disease has been often reported; Dr. C. E. Kellett showed a number of cases of great reduction of complement, estimated by the method of 50 per cent lysis, in a variety of diseases, particularly acute nephritis. This reduction requires further investigation, particularly estimation of the different components.

Blood-coagulation and complement activity involve factors that have a superficial resemblance. Dr. A. A. Sharp reviewed investigations on the relationship between the two systems and could find no evidence that common factors are involved.

Pillemer and his colleagues have shown that the first component promotes the inactivation of the second and fourth components by plasmin[13]. In this reaction, as in the stages of the reaction with sensitized red blood cells, in the conglutinin reaction and in the properdin reactions, we find interactions of the components of complement with one another, set off by an antigen–antibody complex, by a zymosan–properdin complex or by an enzyme. This complicated system of interacting components is found in the serum of all mammals examined and something similar in the serum of birds. Complements have been divided into hæmolytic and non-hæmolytic. This distinction is artificial and due to the customary use, as a test system, of sheep red blood cells sensitized with rabbit or horse antibody; horse complement, which does not lyse this system, lyses rabbit red blood cells sensitized with sheep antibody[14]. The first components of mammals seem to be similar; the difference between guinea pig complement, which is hæmolytic (for sheep cells sensitized with horse or rabbit antibody) but not conglutinating, and horse complement, which is conglutinating, seems to lie in the fourth component[15]. The new methods of investigation, particularly the separation of the stages of interaction as done by Levine and Mayer and the study of enzyme activities, open up new possibilities in the study of these interactions and raise complement from the status of a mere diagnostic reagent.

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THE GIACOBINID METEOR STREAM

A PAPER on "The Giacobinid Meteor Stream", by J. G. Davies and A. C. B. Lovell (*Mon. Not. Roy. Astro. Soc.*, **115**, 1; 1955), gives an account of the radio-echo observations of the meteor shower associated with comet Giacobinid–Zinner during the unexpected return of the shower on October 9, 1952. The shower was first studied by radar in 1946, and the paper gives a description of the observations from 1947 to 1954, inclusive, and also discusses the unexpected return of the shower during daylight in 1952 as well as the significance of its absence in 1953. The equipment for observation has been described by A. Aspinall, J. A. Clegg and G. S. Hawkins (*Phil. Mag.*, **42**, 504; 1951), and, with the exception of the 1952 return, no activity beyond four or five meteors per hour—the background sporadic rate—was detected.

The records for October 9, 1952, are shown graphically, and from these it is obvious that the activity of the Giacobinid radiant became greater

than the sporadic background rate at about 14h. 20m. on this date. A slow rise in activity until 15h. was followed by rapid increase to a maximum at 15h. 40m. on the radiant survey apparatus and at 15h. 50m. on the steerable beam equipment (described in *Mon. Not. Roy. Astro. Soc.*, **107**, 164; 1947). It is suggested that this difference of ten minutes in the time of peak activity may have been due to the slightly different polar diagrams for reception in the two equipments. The matter is fully discussed in the paper, and the following question arises: Considering the intense shower during 1952 when the Earth crossed the cometary orbit 193 days before the comet, why were the results negative in 1953 when the Earth was at the node 172 days after the comet? A discussion of this problem leads to the suggestion that perturbations increased the perihelion distance of the meteors in front of the comet relative to those which followed it; if this view is correct, there is nothing to support the idea that the debris is concentrated near the comet, and in fact there remains the possibility that it is distributed all around its orbit.

Among other interesting data, reference may be made to the shower on October 10, 1946, the curves of activity as measured by the visual, photographic and radio-echo techniques showing a temporary decrease in activity at 3h. 30m., and a similar drop was evident from Canadian observations. While the radio-echo rate reached a maximum at 3h. 43m., the maximum in the visual and photographic rates occurred twelve minutes later. These peculiarities are explicable if a separation of meteor masses had taken place, the main peak in the radio echo curve at 3h. 43m. being due to faint meteors below the photographic and visual limits. While such a separation of the particles could arise from the Poynting–Robertson effect, there are difficulties in accepting this view, and some other explanation must be sought.

REMANENT MAGNETISM OF SWEDISH VARVED CLAYS AND ARTIFICIAL SEDIMENTS

TWO papers under the joint title of "The Remanent Magnetism of Varved Clays from Sweden: the Remanent Magnetism of Artificially Deposited Sediments" have recently been published (*Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **7**, No. 3; 1956), the first being by D. H. Griffiths and the second by R. F. King, both of whom are in the Department of Geology of the University of Birmingham. The first paper describes the attempt to obtain information about the Earth's magnetic field in the past. The investigation commenced with the collection in 1938 of a thousand-year varve series at Prästmon on the Ångerman River, and then a similar thousand-year series collected at Undrom, which lies a few kilometres upstream from Prästmon. This series was older but overlapped the Prästmon varves by about four hundred years. A year later, varves of Glacial age were collected from sections in the vicinity of Ragunda on the Indal River, and in the same year continuous varved cores were obtained from the present delta of the Ångerman River near Kramfors, covering approximately the period A.D. 1300–1900. It was known that the clays to be measured had magnetic moments of 10^{-4}–10^{-6} c.g.s. units/c.c., and a description with a diagram is given of the a.c. magnetometer designed by E. A. Johnson to measure an induced e.m.f. of the order of a microvolt; while this, generally speaking, was satisfactory, it had certain faults which set a limit to the accuracy with which weak specimens could be measured.

About 150 samples were measured, roughly divided between the two localities of Prästmon and Undron, and the total interval covered by the samples was from about 1100 B.C. to A.D. 750, the period covered by the overlap being 150 B.C. to A.D. 250. As a result of the measurements, some tentative conclusions have been arrived at, among which the following may be mentioned. In a favourable environment the polarization directions acquired by varved clays on deposition have directions which, on correction for the tilt of the layers, lie sufficiently close to the Earth's original direction of field to give at least a rough approximation to the secular variation at the time. If, however, the environment during deposition is unfavourable, the polarization directions may be widely scattered and even systematically deviated, and in such cases they may show little relation to the direction of field. This seems to have occurred with the Angerman River delta sediments from which the cores were taken, and it is suggested that the bottom currents are the factor most liable to create an unfavourable environment.

With one exception, these conclusions are in the main substantiated by the laboratory sedimentation experiments of Dr. R. F. King. In this work, a small 'Perspex' tank was made, with arrangements for feeding in a slurry of silt which slowly settled on a tray in the floor of the tank, from which samples could be taken and their directions of magnetization measured. A magnetic field around the tank was provided by Helmholtz coils, and the direction and intensity of the resultant magnetic field were varied, currents being created in the tank. An attempt was then made to discover what factors, other than the magnetic field, controlled the alignment of the permanently magnetized particles which give the sediment its remanent magnetic moment. Two such factors were found to be important—the slope of the surface on which the silt is deposited, and the current flowing in the water immediately above this surface—and as they are known to be operative in Nature, similar effects are likely to occur during natural sedimentation. Even in their absence, however, artificially deposited sediments are not magnetized exactly in the direction of the magnetic field, but at a slightly lower inclination to the horizontal. It is pointed out that this effect may or may not occur in Nature, and is somewhat dependent on the state of dispersal of an artificial sediment during deposition. "All three effects may be explained in terms of a simple model which supposes the sediment to be composed partly of spheres, the alignment of which in the field is perfect, and which can roll on a sloping bed or in a current, and partly of flat particles which settle with the plane containing their magnetic moment horizontal. There is no direct evidence of the existence of large numbers of plate-like particles, and it may be that they occur in quantity only in the special conditions of dispersal to be found in the tank, and not in Nature."

Further work on the nature and distribution of the magnetic particles is in progress, and more recent sediments have been collected from Iceland.

ROLE OF HEXOSE PHOSPHATE IN SYNTHESIS OF CELLULOSE BY *ACETOBACTER XYLINUM*

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DISSIMILATION of carbohydrate may proceed in *Acetobacter* species largely via the pentose cycle[1,2]. Thus, in *A. xylinum*, where synthesis of cellulose depends on oxidation of carbohydrate[3], the possibility is presented that energy for the synthesis might be derived from the operation of the cycle. Synthesis and cycle might also be linked if they proceeded obligatorily via a common intermediate, for example, a sugar phosphate. To clarify these possibilities, three lines of investigation have been pursued: (*a*) determinations of the relative rates and balance-sheets of oxidations of carbohydrates and their conversion to cellulose by cells; (*b*) radioactive tracer analyses of these processes; and (*c*) analyses of intermediary steps of sugar dissimilation effected in a cell-free system. The present communication is a preliminary report on the results obtained.

Washed cells of *A. xylinum* oxidized glucose rapidly to gluconate and the latter then to slowly oxidizable ketogluconates. In addition, the cells possessed a fluoride-resistant phosphorylative system whereby glucose and gluconate could be oxidized rapidly to carbon dioxide. The principal findings are summarized in Fig. 1. They have suggested that carbon dioxide arises in *A. xylinum* largely via a pentose cycle in which it is formed by oxidative decarboxylation of 6-phosphogluconate and from which triose-phosphate is withdrawn by oxidation via phosphoglyceric acid to pyruvate. The latter is then oxidized to acetate and thence via a fluoroacetate-sensitive pathway to carbon dioxide. As to hexose phosphate, the scheme proposes that this arises both directly by phosphorylation of exogenous hexose and from pentose-cycle intermediates, and that it gives rise to cellulose.

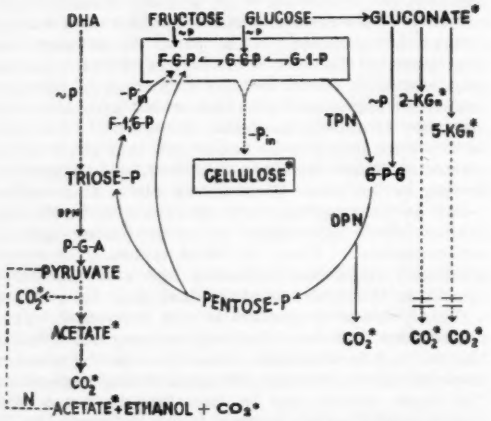

Fig. 1. Production of carbon dioxide and cellulose by *Acetobacter xylinum*

Arrows with continuous line (——→) indicate reactions that have been carried out in cell-free extract of the bacteria. Reactions which have not as yet been carried out in the cell-free system are shown by arrows with a broken line (- - - →). Crossed arrows (—‖→) designate a relatively slow reaction. Asterisk (*) designates products the formation of which in the medium of cell suspensions has been demonstrated by a direct analytical method. *N* = anaerobic pyruvate dismutation.

Fructose was inert towards the glucose-grown cells but was metabolized by fructose-grown cells to the products shown.

Phosphate esters (glucose-6-phosphate, α- and β-glucose-1-phosphate and uridine diphosphoglucose) were not metabolized by the whole cells. As extracts oxidized glucose-6-phosphate and α-glucose-1-phosphate readily, it is assumed that these phosphate esters are inert when added to a cell suspension only because they fail to enter the cell

The use of specifically labelled glucoses in radioactive tracer analyses of cellulose synthesis by *A. xylinum* has been described previously by Minor and co-workers[4]. All their experiments, however, were conducted on cells growing in culture medium containing several carbon sources. The findings could not be interpreted clearly. We have utilized the approach that has been developed by these investigators, but applied it to a simpler test system—that of non-proliferating washed cells suspended in a solution containing but one added carbon source (glucose or fructose).

Cellulose formed from specifically labelled hexoses in washed cell suspensions possessed patterns of carbon-14 distribution which appeared significant when considered in the light of the enzymatic constitution of the cells. If, as proposed in the scheme of Fig. 1, cellulose arises from a metabolic pool of hexose phosphate which is sustained concurrently by direct phosphorylation of free hexose and by reactions of the pentose cycle, it may be expected that the carbon C_6 of the cellulose monomer would be formed exclusively from carbon C_6 of the exogenous hexose, whereas the carbon C_1 of the monomer would be formed to an appreciable degree from carbon C_2 and but partly from carbon C_1 of the exogenous hexose. Degrees of retention and distributions of carbon-14 in celluloses formed respectively from glucose-1-, -6- and -2-^{14}C and fructose-1-^{14}C were found to be in accord with these expectations (Table 1).

Equations which relate the part of non-cycled hexose phosphate in the hexose phosphate pool to a cellulose/carbon dioxide ratio have been formulated and will be presented elsewhere. With their aid, it has been possible to demonstrate that the agreement between theory and the experimental findings in Table 1 is quantitative and not merely qualitative. Furthermore, it is noteworthy that the radioactivity of cellulose afforded by glucose-1-^{14}C is considerably less than that formed by fructose-1-^{14}C. This feature is readily understood in the light of the observation that *A. xylinum* rapidly converts glucose to gluconate. Consequently, only a minor fraction of glucose undergoes phosphorylation as such, and the bulk of glucose

Table 1. CONCENTRATION AND DISTRIBUTION OF CARBON-14 IN CELLULOSE SYNTHESIZED FROM SPECIFICALLY LABELLED HEXOSES
Washed fibril-free fresh xylinum cells were incubated aerobically in 0·005–0·01 *M* radioactive substrate solution buffered by citrate (Na^+) at *p*H 6·4 at 30° until substrate had been exhausted (about 4 hr.). Cellulose was separated, purified and converted to glucose by acetolysis with following hydrolysis (ref. 5). Hydrolysate was freed of anions, concentrated and analysed as to reducing power and carbon-14 content. Distributions of carbon-14 within glucose were obtained by the procedure of Frush and Isbell (ref. 6)

Hexose used as substrate	Radioactivity of cellulose formed			
	Activity of monomer relative to substrate ($100 \times S_m/S_A$)*	Distribution of activity within monomer (as per cent of S_m) moiety		
		C_1	C_2–C_5	C_6
Glucose-^{14}C (evenly labelled)	90–100†	15†§		
Glucose-2-^{14}C	78–91	47	53	0
Glucose-6-^{14}C	96–100	0	0	100
Glucose-1-^{14}C	7–11			
Fructose-1-^{14}C	35–40‡			

* Specific molar radioactivities of substrate and cellulose monomer are designated respectively S_A and S_m. Values in column show the maximum range of variation of the results found using different batches of cells in two experimental series, each carried out in replicate. Carbon-14 concentrations in cellulose formed respectively by freeze-dried and fresh cells have been found to be similar.
† Freeze-dried cells were used.
‡ Fructose-grown cells were used.
§ C_1 was recovered in phenylphenacyl formate prepared from glucose of cellulose hydrolysate as recommended by Sowden (ref. 7).

carbon can only be introduced into the hexose phosphate pool indirectly via a pentose cycle which is operating on gluconate. Fructose, on the other hand, must all first enter the pool directly, and hence this hexose is able to maintain a pool in which a larger fraction of hexose phosphate is contributed by the exogenous substrate without intermediary cycling. Since carbon C_6 of hexose did not label carbon C_1 of the cellulose monomer detectably, it can be inferred that triose-phosphate dehydrogenase competed effectively with aldolase in this cell for the triose-phosphate formed during the operation of the pentose cycle.

In summary, the results of this study suggest that cellulose can be formed in *A. xylinum*, as probably in green plants[8,9], from hexose phosphate by a process which is direct in the sense that it does not require intermediary cleavage of the carbon skeleton of the hexosyl residue of hexose phosphate. In addition, the conclusion can also be supported that the pentose cycle operates in *A. xylinum* in the living cells as well as in its extracts.

Since essentially all the cellulose of *A. xylinum* is laid down extracellularly, it has been inferred that the polymerization step in this synthesis is either catalysed by the cell surface or occurs spontaneously in the medium from a diffusible precursor[8]. Since hexose phosphate as such is probably unable either to enter or leave the cell, the possibility can be favoured that hexose phosphate yields cellulose via a diffusible intermediate which contains the carbon skeleton of hexose phosphate but in which the phosphate group has been either modified or replaced.

This investigation, which is being continued, will be reported elsewhere in detail. Preparations of specifically labelled glucose were kindly placed at our disposal by Dr. H. S. Isbell.

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CHEMICAL INDUCTION OF CROSSING-OVER IN *DROSOPHILA* MALES

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IN the progeny from female structural heterozygotes which had been injected with formaldehyde, unusual recombinants were observed. This led us to the assumption that formaldehyde can induce crossing-over in a genetical situation where it is normally inhibited. The idea was further tested on males, where crossing-over is naturally rare, or does not occur. After injection with mutagenic concentrations of formaldehyde, clusters of identical and complementary cross-over classes were observed. This suggested that crossing-over induced by formaldehyde in males predominantly occurs in the spermatogonial stages[1].

It was thought of interest to investigate whether formaldehyde shares this property of inducing crossing-over with other mutagenic chemicals. For the preliminary investigation reported here, formaldehyde, dihydroxydimethyl peroxide and mustard gas were used.

Males heterozygous for the markers *black*, *purple* and *vestigial* were treated with mustard gas, or injected with either the organic peroxide or formaldehyde. Some of the experiments were combined with tests for sex-linked lethals by back-crossing the treated males individually to three females of the genotype *Basc*/+ ; *b pr vg* at three-day intervals, so that four broods representing successively younger stages of spermatogenesis were obtained. This method enables scoring of recombinants in the F_1 and of sex-linked lethals in the F_2 of the same males.

The results on induced crossing-over are set out in Table 1 and those on the mutagenic effectiveness of the various chemicals in Table 2.

In every brood individuals showing one or two of the marker genes were observed; they were all scored as recombinants (r). This seems the correct interpretation for most of the specimens exhibiting two neighbouring marker genes (r_1), though alterna-

Table 1. The Frequency of Recombinants in Successive Broods from Males which had been treated with Different Chemicals, heterozygous for *b pr vg*, and *b pr vg* Females. (♂♂ *b pr vg*/+ + +, ♀♀ *Basc*/+ ; *b pr vg*/*b pr vg*)

Chemical treatment Concentration and amount injected	Total offspring (*n*) and recombinants (*r*) showing one (r_1) or two (r_2) of the recessive markers											
	Brood *b* (4–7)				Brood *c* (7–10)				Brood *d* (10–13)			
	n	*r*	r_1	r_2	*n*	*r*	r_1	r_2	*n*	*r*	r_1	r_2
Formaldehyde 0·042 *M* 0·27 mm.³	8,469	{1 *b pr* {1 *vg* 2 *b* 1 *pr* {3 *vg** 1 *vg*	8	1	3,913	1 *pr vg* {3 *vg**	3	1	8,595	{6 *b pr* {2 *vg* {1 *b pr* {2 *vg* {1 *b pr* {1 *vg* {4 *b pr* {3 *b pr* 4 *b pr* 2 *vg*	7	19
Dihydroxydimethyl peroxide 0·019 *M* 0·21 mm.³	4,240	—	—	—	6,575	{1 *b* {1 *vg* 1 *b* 1 *vg*	4	—	6,936	{1 *b* {2 *pr vg* {1 *b* {1 *pr vg* {2 *b* {1 *pr vg* {1 *b pr* {1 *vg* {2 *b pr* {1 *vg* {2 *b pr* {3 *vg* 2 *b* 3 *b pr* 1 *vg*	12	12
Mustard gas Exposure 2 min. at 18·5° C.	3,198	—	—	—	4,865	1 *b* 1 *b*† 1 *vg*	3	—	4,545	2 *b pr* 1 *b* 1 *vg*	2	2
C. Auerbach‡	4,667	—	—	—	2,720	—	—	—	2,021	—	—	—

Recombinants in the progeny of the same male are bracketed together ; all other recombinants occurred independently in different males.

* The clusters of *vg* flies in broods *b* and *c* of the formaldehyde experiment were all derived from the same male.

† A dead specimen in which the presence of *apricot* did not enable the scoring of *purple*, so that *b pr* cannot be excluded.

‡ Unpublished data of Dr. C. Auerbach. Except for the constitution *b cn vg*, her experimental procedure was identical with the one reported here.

tive possibilities are duplication or suppression of one locus, or reverse mutation, especially at the *black* locus. Those with only one marker gene (r_1) could also be due to either mutation or deficiency. In brood *d* proper cross-overs were much more frequent than in the later broods. Clusters of recombinants are clear proof that this brood is sampled from treated spermatogonia. Even the r_1 specimens in this brood could be due to crossing-over, especially when they occur together with the complementary r_2 class.

From a quantitative point of view, it is of interest that mustard gas, which is one of the most potent chemical mutagens, produces fewer cross-overs relative to induced mutations than the organic peroxide and formaldehyde which are much weaker mutagens. In this respect they are in good agreement with unpublished data of Auerbach (see Table 1), who, using a comparable mustard gas concentration, did not observe crossing-over. Whittinghill[2] reported that nitrogen mustard increased crossing-over in females in the spindle-attachment region ; more detailed data of his observations are not available.

There is, however, a remarkable similarity between the frequency of crossing-over induced by formaldehyde and dihydroxydimethyl peroxide and by X-irradiation (cf. Auerbach[3] and Whittinghill[4]). It is possible that this correspondence is more than a mere coincidence. Evidence has recently been presented that the formation of peroxides is presumably involved in the production of mutations by X-rays[5] and that peroxides also play a part in formaldehyde mutagenesis[6]. It is less certain whether peroxides are of similar importance in the production of mutations by mustard gas. The data on the induction of crossing-over might therefore serve as further support for the idea that the formation of peroxides is of importance in the action of certain mutagenic agencies. In this connexion it is of interest that, according to Meyer's[7] observations, ultra-violet light also induces crossing-over in *Drosophila* males.

In these experiments, as in those of Auerbach and Whittinghill, induced crossing-over in the male has been mainly produced in the spermatogonial stage. For X-rays this has been interpreted in different ways. Whittinghill holds the view that crossing-over actually takes place in the spermatogonia. Parker[8], on the other hand, thinks that induced crossing-over is taking place in cysts of spermatocytes. The cluster effect is then explained by assuming similar conditions for all cells within a cyst. The present experiments do not allow us to decide between these two explanations.

Depending on the theory of crossing-over which one accepts, it would seem that the induction of

Table 2. Frequency of Sex-linked Lethals in Successive Three-day Broods from Males which had been treated with Different Chemicals in Concentrations as indicated in Table 1

The same males were used for the crossing-over tests in Table 1

Chemical treatment	Sex-linked lethals							
	Brood *a*		Brood *b*		Brood *c*		Brood *d*	
	n	% 1	*n*	% 1	*n*	% 1	*n*	% 1
Formaldehyde	1,020	3·9	—	—	—	—	—	—
Dihydroxydimethyl peroxide	630	0·5	622	1·3	524	1·3	795	1·6
Mustard gas	565	4·2	582	4·1	494	7·5	523	3·6
„ C. Auerbach	516	4·8	742	6·1	470	8·9	565	3·3

crossing-over could also be used as a measure of chromosome breakage. The present results would then suggest that breakage is not an altogether uncommon event after injection with formaldehyde and dihydroxydimethyl peroxide. It is not yet possible to decide whether one or two breaks are involved in the initiation of chemically induced crossing-over. No data are available on the capacity of injected formaldehyde to induce gross re-arrangements. A concentration of dihydroxydimethyl peroxide with a mutagenic effectiveness similar to the one used in this study produced one 2–3 translocation in 441 gametes in brood *a* and none in three other broods sampled between the fourth and tenth day after treatment with 1,388 gametes tested (unpublished work).

In correlation with mutation studies, the induction of crossing-over can serve as a useful tool for the location of the subsequent stages of spermatogenesis. Such a study aimed at more information on the possible similarities between the mutagenic effects of formaldehyde administered by injection and by feeding, and of dihydroxydimethyl peroxide, is in progress.

In connexion with our results, the observations of Levine[9] seem of interest. He found that a deficiency of calcium caused a significant increase of ordinary, meiotic crossing-over. Similar observations were made in *Chlamydomonas* by Eversole and Tatum[10] after treatment with ethylenediamine tetraacetic acid and manganese chloride. We do not know whether our observations on the induction of gonial crossing-over are biochemically related to those of Levine and Eversole and Tatum.

We wish to express our gratitude to Dr. C. Auerbach for reading the manuscript and for the use of her unpublished data. [Sept. 25

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ULTRA-STRUCTURE OF THE GOLGI APPARATUS IN PROTOZOA AND METAZOA (SOMATIC AND GERMINAL CELLS)

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THE study of very thin sections examined with the electron microscope permits the formulation of a general view on the ultra-structure of the Golgi apparatus in protozoa as well as in metazoa.

We have already shown[1–3] that the Golgi apparatus appears with a great structural constancy in all the animal cells. Our investigations did not, however, include the neurons of vertebrates.

The parabasal apparatus of zooflagellates, the dictyosomes of somatic and germinal cells, the Golgian 'cords' of secretory cells have the same composition and are without doubt strictly homologous elements, belonging to the same category of cellular constituents.

The chromophile part (reducing osmium) of the Golgi apparatus is not composed of tubules, but of very flat *saccules*, the walls of which enclose a slit-shaped area (Fig. 1). The very numerous sections of dictyosomes which we observed cannot correspond to sections of tubules, since whatever their orientation (even transverse) they never show small circles, but always *slits* of a variable length according to the organs and the species under consideration. These slits are limited by very conspicuous membranes. These features can only be explained if the flattened saccules are square, lozenge-shaped or rectangular.

It is the walls of the saccules which show osmiophily, whereas the internal area always appears brighter.

In fact, the saccules are so flattened that one could interpret them as being double membranes. But observation shows on all the sections that the edges of the saccules are closed and show no interruption. Indeed, we thus have here flattened saccules with closed edges.

The second constant element of the Golgi apparatus consists in numerous osmiophile vesicles (osmiophile bodies of Dalton and Felix[4]) placed in the immediate neighbourhood of the pile of saccules. They are sometimes situated along the latter, resembling a garland. The vesicles, ellipsoid in shape, are limited by a thin osmiophile membrane, appearing, on the electron micrographs, darker than the contents.

These two elements, that is, saccules and osmiophile vesicles, never fail and are closely associated.

The osmiophile vesicles arise from the saccules, and all the numerous micrographs we have made of the Golgi apparatus indicate this. They can become loose from the edges of the saccules, where they appear as droplets or pearls; or the saccule breaks wholly or partly into fragments which constitute as many vesicles.

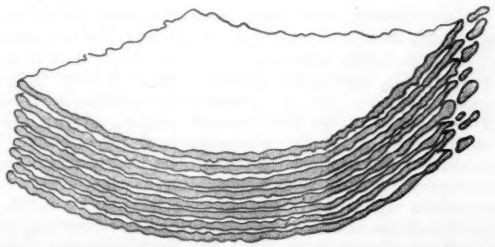

Fig. 1. Drawing of a dictyosome, with the osmiophile vesicles becoming loose from the edges of the saccules

Fig. 2. (1) Young spermatid dictyosome (part of an idiozome) of the snail, *Helix pomatia*. Numerous osmiophile vesicles are observed above, below and in the immediate neighbourhood of the pile of saccules; (2) spermatocyte dictyosome (part of an idiozome) of a West African millipede, *Spirostreptus castaneus*. No large vacuoles or vacuolary areas in the neighbourhood of the dictyosome; (3) dictyosome of the snail (*Helix pomatia*) multifid gland; very numerous osmiophile vesicles; no large vacuoles in the neighbourhood of the dictyosome; (4–6) parabasal apparatus of zooflagellates; (4) of *Joenia annectans* (from *Calotermes flavicollis*); *F*, parabasal filament; (5) of *Foania dogieli* (from *Calotermes flavicollis*); numerous osmiophile vesicles getting loose from the edges of the saccules; (6) of *Trichonympha* (from *Reticulitermes santonensis*). (1, 3, 4 and 5) × 33,500 (original magnification, 20,000); (2) × 50,000 (original magnification, 30,000); (6) × 30,000 (original magnification, 17,300)

The following are some concrete cases of Golgi apparatus studied by us or our students: the idiozome of *Helix pomatia* (gasteropod mollusc) spermatid (Fig. 2; 1)[3], of *Spirostreptus castaneus* (West African millipede) (Fig. 2; 2)[5], of *Discoglossus pictus* (anuran amphibian)[1]. The dictyosomes gather around the centrosome, and the acrosome (or pro-acrosome) becomes differentiated among the intra-idiozomal substance; the dictyosomes have the ordinary structure which we have just described. The osmiophile vesicles are more or less numerous according to the stage of spermiogenesis. We have observed their fusion ending in the formation of a network[3]. No large vesicles, vacuoles or vacuolary areas are seen in the neighbourhood of the *Spirostreptus* dictyosomes[5].

In the snail oocyte, the scattered dictyosomes have the same constitution as those of the idiozome, but their saccules show more swollen edges. Dictyosomes have been seen containing an osmiophile homogeneous mass in their cavities. Is it a vitellus granule? There is no evidence that such granules arise in the Golgian saccules.

The Golgi apparatus of multifid glands (*Helix pomatia*) (Fig. 2; 3) is composed of big osmiophile saccules, the piles of which follow each other in parallel to the longitudinal axis, which gives the powerful chromophile 'cords', disclosed by osmic impregnation under the light microscope. The osmiophile vesicles are very numerous.

One of our students (Berkaloff, unpublished work) has just demonstrated the Golgi apparatus in the leucocytes and the pericardial cells of *Gryllus domesticus*, where they have the same features as in the multifid glands of the snail.

The parabasal apparatus of zooflagellates (*Joenia*, *Foania*, *Trimitus*, *Spirotrichonympha*, *Trichonympha*) has precisely the structure of dictyosomes[3]. The filament which joins it to the centrosome has been demonstrated again by electron microscopy. The osmiophile vesicles are always numerous (Fig. 2; 4, 5, 6). We have observed, in *Joenia*, a case of dictyocinesis; the latter is achieved by a transverse division of the saccules, which confirms their interpretation as fundamental elements of the dictyosomes.

Bringing together pictures obtained by light and electron microscopy enables one to claim that the chromophile part of the dictyosomes, recognized as early as 1920 by Bowen, corresponds to the piles of saccules. The osmiophile vesicles are too small (20–30 mμ by 60–120 mμ in the snail spermatid) to be distinguished under the light microscope.

If one sticks only to observed facts, one is led to admit that the elements of the Golgi apparatus constantly present and disclosed by electron microscopy are the saccules superposed into piles, and the osmiophile vesicles which accompany them and which arise from them. One is very tempted to establish a genetical link between the osmiophile vesicles and big vesicles or vacuoles sometimes observed in the cytoplasm in the neighbourhood of the dictyosomes; but the establishing of a genealogy on the simple examination of sections is always difficult and involves a partly subjective interpretation. Classical cytology offers very numerous examples of mistakes made through the application of this method. More-

over, the frequently observed absence of any vacuolar formation in the neighbourhood of numerous dictyosomes (millipede spermatocyte and spermatid, *Gryllus* leucocytes, snail multifid glands, and so on) producing, however, a great quantity of osmiophile vesicles, is an argument for the absence of relationship between the vacuoles and the saccules or the osmiophile vesicles.

But what then is the chromophobe part of the dictyosome, the existence of which cannot be doubted? It not only appears very clearly in light microscopy after osmic impregnation, but is furthermore brightly coloured by the green-light dye, and it is not difficult to see it *in vivo* in the spermatocytes, or in the cells of the multifid glands, of the snail (*Helix*), and in the large symbiotic flagellates of termites.

It has often been asserted that the large bright vacuolar areas which are close to the osmiophile saccules participate in the chromophobe substance[4]. We cannot agree with this interpretation, as such areas are far from being constant and fail in the large dictyosomes (parabasal apparatus) of flagellates which, examined with the light microscope, are yet rich in chromophobe substance. We are inclined to believe that the cytoplasm, in contact with the pile of saccules, acquires a higher index of refraction than that of the surrounding cytoplasm, and also peculiar tinctorial properties, but does not correspond to a really differentiated structure.

Our conclusion is the following: the Golgi apparatus, like the mitochondria, is an autonomous cell element and also has its own structure. The former ideas concerning the Golgi vacuome or the Golgi arising from the mitochondria are nowadays out of date. The dictyosomes are always distinct from the ergastoplasma (Garnier, 1897) or endoplasmic reticulum of the American authors, even when the latter is very abundant, as is particularly the case with insect leucocytes (unpublished work of Berkaloff). For two different reasons we believe that the Golgi apparatus of vertebrate as well as of invertebrate neurons is composed of separated dictyosomes: (1) in chicken neuroblasts, the dictyosomes are clearly individualized and gathered around the centrosome[7,8]; (2) Palay and Palade[9] have given electron micrographs of neurons belonging to various nerve centres of the rat. In these, one clearly sees sections of typical dictyosomes (osmiophile saccules and vesicles) wrongly interpreted, according to us, by these authors, as "agranular reticulum" (endoplasmic reticulum). Couteaux (unpublished work) has just observed with the electron microscope typical dictyosomes in the ganglionic neurones of the leech (*Hirudo medicinalis*). What relation can exist between these dictyosomes and the "internal reticular apparatus" of Golgi (1898) is not yet understood.

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THE BANK VOLE IN CAPTIVITY

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Seasonal Breeding in Captivity

THE breeding season of most small mammals in Britain extends from the spring throughout the summer months until some time in the autumn and is generally followed by a period of anœstrus among the females during the winter months. The bank vole, *Clethrionomys glareolus*, has been found to breed from April until October with maximum reproductive activity in June[1], though there is evidence from parts of the country of some breeding throughout the winter in certain years[2]. Records during June 1950–May 1955 of the breeding of a colony at the Department of Zoology of the University of Edinburgh suggest that the reproductive activity of this species may be more variable and less clearly seasonal than is commonly thought to be the case. The colony was kept in twenty-four large cages in the open air throughout the five-year period, and, except for an ample food supply at all times, the conditions under which the animals lived and bred probably approached to the wild state as closely as is possible for animals in captivity. The number of litters born in each month during the whole period is shown in Fig. 1, and the corresponding figures for each year listed in Table 1. Some litters were born in the winter months each year except 1950–51. In other years breeding continued throughout the winter at a low rate and began to increase in either February or March. The peak of reproductive activity was reached in either April, May or June and tended to

Table 1. Monthly Record of Litters Born during June 1, 1950–May 31, 1955

Month	1950–51	1951–52	1952–53	1953–54	1954–55	Total for month, over 5 year period
June	4	8	6	12	4	34
July	3	5	11	3	7	29
August	4	13	6	4	4	31
September	0	7	7	6	7	27
October	2	6	3	2	5	18
November	0	7	3	2	3	15
December	0	4	1	2	0	7
January	0	5	3	1	2	11
February	4	4	7	0	0	15
March	3	9	11	3	6	32
April	4	8	21	1	11	45
May	8	11	15	8	4	46
Total for year	32	87	94	44	53	310

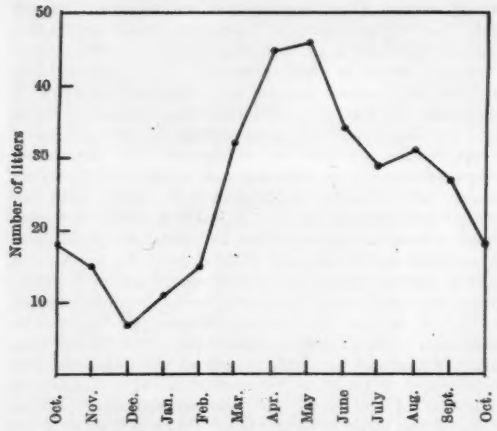

Fig. 1. Total number of litters born each month, 1950–55

decline thereafter, though remaining high during the summer months.

Most published information on the breeding seasons of small mammals is based on the examination of samples of wild populations collected by trapping. Although the total number of animals studied during a whole year may be considerable, the number of females taken during the winter is usually rather small. It is suggested, therefore, that a modest proportion of breeding females in the population during these months may easily be missed.

The amount of winter breeding in any year cannot be correlated simply with any obvious climatic variable and seems more likely to be related to the age structure and fecundity of the animals forming the colony. Although the evidence for this cannot be discussed here, it was noted that most of the litters during the winter were born to females which had maintained a high rate of reproduction throughout the preceding summer and autumn.

Variation of Gestation Time

Information on the normal range of variation of gestation time among feral mammals is scanty compared with the data available for man and domestic animals, and most of it is based upon estimates by indirect methods or scattered observations of small numbers of pregnancies[3,4]. Accurate estimates can, however, be obtained for Microtinae and other small rodents in which a post-partum œstrus and re-impregnation of the female commonly occurs within a few hours of parturition. In these circumstances litters are born at intervals of about three weeks, and the duration of pregnancy may be regarded as approximately the same as the interval observed between the birth of successive litters. The following information was obtained from a colony of bank voles at Edinburgh. This colony included four morphologically distinct forms and hybrids of them, but for the present purpose they are treated as a single freely interbreeding population. Fig. 2 shows the interval observed between the birth of successive litters for all cases where this interval was thirty days or less, and includes 114 litters born to twenty-seven females. The distribution is markedly skewed, with the mode at twenty days. It is clear, however, that the duration of most pregnancies is less than twenty-five days, and if those of longer duration are discounted the distribution of the remaining ninety-three litters is roughly symmetrical around a mean of $20{\cdot}6 \pm 0{\cdot}17$ days. The justification for this procedure is that pregnancy may sometimes be prolonged by continued lactation of a previous litter, or failure of impregnation at the post-partum œstrus may be followed by successful impregnation at the following œstrus four or five days later. The small secondary peak at twenty-five and twenty-six days suggests that the latter alternative occurs not infrequently.

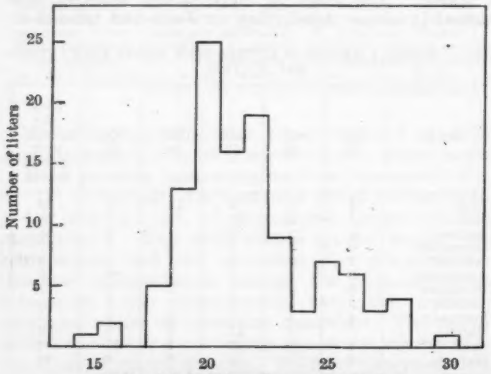

Fig. 2. Distribution of gestation times for *C. glareolus* estimated from the interval between the birth of successive litters

It is instructive to compare these data for *Clethrionomys* with similar data for women and other mammals, since it is widely believed that the duration of gestation in women is more variable than in other species. Some coefficients of variation for gestation time of different species are shown in Table 2. It is apparent that while the variance for most breeds of domestic animals is less than that of women, the value obtained for *Clethrionomys* is more than twice as great as any other species.

Table 2. Variance of Gestation Time for Man and some other Animals

	Average duration of pregnancy (days)	Standard deviation	Coefficient of variance (per cent)
Man (various sources)	about 280	± 9·2–10·4	3·3–4·0
Clethrionomys glareolus	20·6	± 1·67	8·1
Horse—Clydesdale	332·8	± 10·5	3·16
Rhein-Belgian	332·6	± 7·2	2·16
Cow—Aberdeen Angus	282·5	± 3·60	1·27
Norwegian	285·8	± 5·7	1·99
Ayrshire	277·8	± 4·3	1·55
Pig	128 0	± 3·0	2·35
Sheep—Rambouillet	148·6	± 2·25	1·52

Although based upon a relatively small series of observations this finding suggests that the normal variation for the duration of pregnancy of feral mammals may be at least as great as that of human beings. The low variance of most domesticated animals is probably due mainly to the precision of the estimate obtained by controlled mating, but there may also be a selection effect associated with the degree of inbreeding.

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LETTERS TO THE EDITORS

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Experimental Verification of the 'Clock-Paradox' of Relativity

EINSTEIN'S theory of relativity predicts that if one of twin brothers leaves home in a space ship and spends a considerable amount of time travelling at high velocity with respect to his home inertial frame, then, when the traveller returns home, he will find himself physiologically younger than his stay-at-home brother, and his pocket watch will have performed correspondingly fewer revolutions.

In order to guarantee the above prediction, three assumptions are sufficient: (1) The time dilation of special relativity holds for uniform motion. (2) The acceleration of an ideal clock relative to an inertial system has no influence on the rate of the clock, and the increase in the proper time of the clock at any time is the same as that of the standard clocks in the system in which the clock is momentarily at rest[1]. (3) The traveller and his pocket watch are good approximations to an ideal clock. (The accelerations must not kill the traveller or break his watch.)

The description of the trip from the point of view of the traveller's (non-inertial) rest frame is complicated by the accelerations. This complication has led historically to the name 'clock-paradox'. The 'paradox' can be 'resolved' by the use of general relativity[2,3]. (However, even to describe the trip from the traveller's accelerating frame, special relativity plus assumptions 2 and 3 are sufficient (H. Stapp, private communication).)

An experimental test would be highly desirable, because (*a*) there is not universal agreement that relativity actually does predict the asymmetrical ageing[4], and (*b*) assumption 2 does not follow from special relativity[1]. Verification of the 'clock-paradox result' would therefore require that assumption 2 be included in any correct generalization of special relativity.

In order to look for an asymmetrical ageing effect, it is not necessary for the traveller to make the usual round trip. He can make a one-way trip, stop at his destination, and then compare his age with the stay-at-home twin by means of radio signals. This follows from the basic assumption of special relativity that a common time can be defined everywhere in a given inertial frame (the home frame) by use of local clocks that have been synchronized by means of light signals[5]. The traveller can compare his pocket watch with a *local* clock at his destination, after he is at rest in the home frame. As an additional test, he could then return home at a comparative snail's pace, and compare his pocket watch directly with that of the stay-at-home. He would find that the age difference acquired during the fast outward trip is maintained unchanged during the return trip, provided that the traveller's return velocity is small enough. This follows from the fact that

$$(c/v)\left\{(1 - v^2/c^2)^{-1/2} - 1\right\} = 1/2(v/c) + \ldots$$

tends to zero as $v/c \to 0$.

Mesons are clearly a suitable substitute for brothers[6]. A simple accelerator experiment would use a uniform, parallel beam of mono-energetic π^+ mesons impinging on two identical detectors located at different distances from the target producing the mesons. Variation of the meson flux with distance from the target would check assumption 1. To check assumption 2, the mesons would be decelerated to rest at each detector, and the number of decays at rest compared to the number of incident pions.

The corresponding one-way trip differs from that mentioned above, since it begins with both brothers at the same place and at relative rest in a moving inertial frame, and ends with them both at relative rest but separated in a new inertial frame (the laboratory). This trip has the virtue that it is completely symmetrical in the treatment of the two brothers, *except* that one of them is decelerated while they are together, the other when they are apart. An argument commonly used in trying to make the asymmetrical ageing plausible is that the asymmetrical behaviour of the accelerometers (or stomachs) of the brothers can distinguish the one who travelled from the one who stayed home. In our experiment that argument breaks down completely, although it is easily shown that assumptions 1, 2 and 3 still predict asymmetrical ageing. (It turns out that whichever brother accelerates into the other's rest frame *while the brothers are separated* will remain the younger (and is therefore by definition the 'traveller'), irrespective of which brother was originally accelerated, when they were together, to produce the relative motion.)

This proposed experiment has already been performed implicitly. The first quantitative check of assumption 1 is contained in the combined experiments of Rossi, Hilberry and Hoag[7], Rasetti[8], and Blackett[9]. Rossi *et al.* measured the decrease in μ-meson flux between mountain altitudes and sea-level, and by measuring and correcting for that part of the loss that was due to ionization-energy loss of the mesons in the air-path, they arrived at a mean life-time for decay in flight of about 30×10^{-6} sec. From the measurements by Blackett on the momentum distribution of μ-mesons at sea-level, Rossi *et al.* deduced a mean value for $(1 - \beta^2)^{-1/2}$ of about 15, from which they predicted a mean decay life-time of about 2×10^{-6} sec. for μ-mesons at rest. Rasetti later measured the mean life of μ-mesons at rest and obtained $(1{\cdot}5 \pm 0{\cdot}3) \times 10^{-6}$ sec. Thus assumption 1 has been verified.

In the Rossi experiment, the flux is measured at two places, *without appreciable deceleration* of the mesons. But the 'twin paradox' is not even qualitatively discernible in any experiment that does not involve relative accelerations, for then the brothers never separate, or else never return. In order to complete the experiment, it is necessary to decelerate the μ-mesons and observe their decay at rest—once at mountain altitudes and once at sea-level. Given assumption 1, the only way in which Nature can avoid asymmetrical ageing is by causing the sea-level mesons to undergo anomalously large ageing during their deceleration to rest, such that when at rest they have the same age as the mesons which were stopped at the mountain absorber and have been decaying at the normal rate. The excess decays during deceleration lead to correspondingly fewer decays at rest. This peculiar behaviour cannot be ruled out by special relativity alone, but *is* ruled out if we add assumption 2. It is apparent that the same asymmetrical ageing will also result from a weaker assump-

tion than No. 2, namely, that any anomalous ageing due to acceleration alone is independent of the history of the particle. To verify assumption 2, we must show that *no* anomalous ageing occurs during acceleration.

This last necessary experiment has been performed. Harold Ticho observed the decay of positive μ-mesons that had been decelerated to rest. The experiment was performed[10] at 11,500 ft. and at 600 ft. (Chicago) with the same apparatus (H. Ticho, private communication). Fast incident muons triggered the counter system; delayed counts due to radioactive decay at rest were then observed. From the known momentum spectrum of the mesons at sea-level and at mountain altitude and the calculated geometrical efficiencies, Ticho could predict the number of fast muons that should stop in the absorber at either place and register their decays. If there were no asymmetrical ageing, Ticho would have observed at Chicago a rate anomalously reduced by a factor of about 40. Instead, Ticho observed roughly the expected number of decays at rest, both at low altitude and at high altitude. Thus, assumption 2 has been verified.

I conclude that the experiment that we have proposed for testing the clock-paradox result has already been carried out, through the combined experiments of Rossi, Hilberry and Hoag[7], Rasetti[8], Blackett[9], and Ticho (ref. 10 and private communication). Their results verify the asymmetrical ageing predicted by Einstein's theory of relativity.

I am grateful to Drs. Stelpen Gasiorowicz, Joseph Lepore, Maurice Neumann, Wolfgang K. H. Panofsky and Henry P. Stapp for illuminating discussions. This work was done under the auspices of the U.S. Atomic Energy Commission.

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Experimental Determination of Atmospheric Infra-red Radiation

Much attention has centred on the radiative heat transfer properties of the atmosphere since about 1900, especially with regard to the infra-red absorption of certain atmospheric constituents such as water vapour, carbon dioxide and ozone, the spectral characteristics of which are presumably better known from the application of quantum mechanical methods to the problem. Actual results in terms of atmospheric behaviour, however, are necessarily arrived at by devious methods, usually involving some sort of radiation chart, such as Elsasser's[1]. The experimental confirmation of these methods is almost completely lacking, except at the surface of the Earth, where conditions are similar to those reproducible in the laboratory.

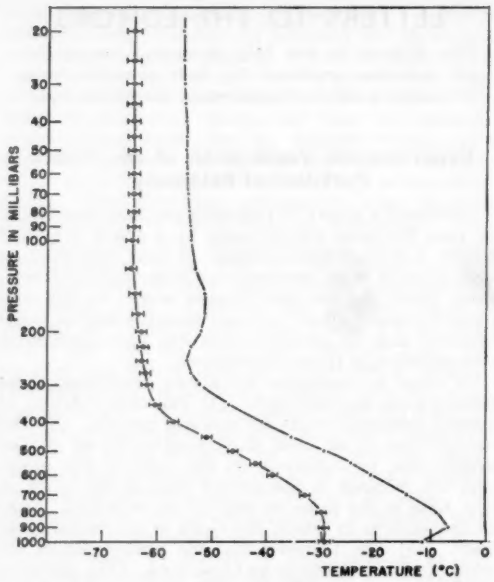

Fig. 1. Average air and equivalent radiation temperatures over Minnesota for February 1956 (18 flights). ●, Average air temperature; ○, average radiation temperature

Since December 1954, 372 radiosonde flights carrying a new total radiation instrument, the 'black ball', have been flown near Minneapolis, Minnesota. This device[2], which is used in connexion with a standard radiosonde unit, is extremely simple and indicates a temperature which is proportional to the total (up plus down) radiation of all frequencies incident on the body at any altitude. The temperatures indicated must be corrected, the results of the correction serving roughly to double the difference between the radiation temperature and the air temperature. The black ball is spherical so that the resulting equivalent radiation temperature is not quite that which would apply to a horizontal disk. The spherical symmetry is advantageous, however, since for such a shape, the difference between the indicated radiation temperature and the air temperature at some altitude is directly proportional to the radiative cooling (or warming) of the atmosphere at that point.

The results of the flights have led to a consistent set of averages of air and radiation temperatures over Minnesota (45° N.) for the months February–October, inclusive. Two such averages, shown in Figs. 1 and 2, for the months of February and August, indicate the extreme changes that take place with season. It is seen immediately that in February the atmosphere is everywhere being cooled by radiation, while in August an extensive region of the atmosphere near the tropopause is being *warmed*. The lower point at which radiative equilibrium holds (about 250 mb.) corroborates King's prediction[3].

A comparison of the measured radiation temperatures on clear nights, with those calculated from the

Elsasser chart using both the linear and square-root pressure correction[4], shows definite disagreement, the actual loss of energy to space being considerably less than either of the above calculations shows. For example, in August, Fig. 2 shows that the equivalent radiation temperature at great altitudes is about − 57°, while the linear pressure correction in the Elsasser chart gives about − 45° and the square-root pressure correction about − 48°.

Houghton and Brewer[5] have published preliminary infra-red radiation results which are not in agreement with the black ball measurements. Previous measurements (unpublished), made at Minnesota with an instrument of the general type they used, from May 13, 1953, to the start of measurements with the black ball in December 1954, indicate the great uncertainty in the results due to equivocal calibrations and in particular due to the spectral characteristics of the window. Although useful for divergence measurements, the absolute readings are questionable.

In any event, there is good reason for believing that the radiation charts require revision. Perhaps a new chart embodying the newer absorption data[6] would be worth while. However, the extreme ease with which radiation data are obtainable using a black ball will allow meteorologists to obtain divergence data (radiative cooling and warming) directly.

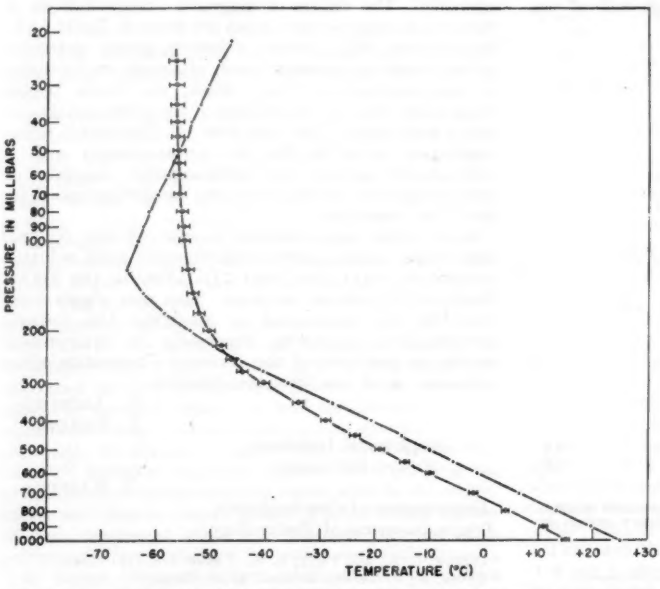

Fig. 2. Average air and equivalent radiation temperatures over Minnesota for August 1955 (26 flights). ●, Average air temperature; ○, average radiation temperature

Most of the radiation data so far obtained have been from the vicinity of Minneapolis, where the results show a consistent yearly trend, although measurements for the months of November, December and January are too few to warrant analysis. A complete analysis of the data will be given elsewhere. At present, the U.S. Navy is flying twenty black ball flights at the south pole, but other radiation data at various latitudes are needed. It is hoped that systematic coverage of at least part of the Earth's surface through many degrees of latitude will be made with black ball flights during the International Geophysical Year.

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The $TiFe_2O_5$—Ti_2FeO_5 Solid Solution Series

IT has already been reported[1,2] that a stable compound having a chemical composition near $TiO_2.Fe_2O_3$ can be produced by ultimate oxidation of the ilmenite–hæmatite mineral series, $x FeTiO_3.(1-x)Fe_2O_3$, or titanomagnetites, $y Fe_2TiO_4.(1-y)Fe_3O_4$. Very little is known, however, about the chemical composition, crystal structure, magnetic properties or other physical and chemical properties of this ultimate oxidation product. In the course of comprehensive research on crystallographic and magnetic properties of the FeO—Fe_2O_3—TiO_2 ternary system, we have succeeded in synthesizing the $TiO_2.Fe_2O_3$—$2TiO_2$.FeO solid solution series, and have examined the magnetic and crystallographic properties of samples of it. It seems that the $TiO_2.Fe_2O_3$—$2TiO_2$.FeO series comprises, together with titanomagnetite and the ilmenite–hæmatite series, the three significant solid solution lines in the FeO—Fe_2O_3—TiO_2 ternary system diagram.

$2TiO_2$.FeO was prepared in the following way. A fine powder mixture of pure Fe_2O_3, TiO_2 and Fe in a stoichiometric ratio, sealed in a quartz tube evacuated approximately to 10^{-3} mm. mercury, is quenched from 1,150° C. after being maintained at this temperature for 2 hr. Analysis by means of a 'Norelco' X-ray spectrometer shows that this specimen is composed of a single phase having the same crystal structure as that of TiO_2. Fe_2O_3 (pseudobrookite), which was easily prepared by heating the mixture of Fe_2O_3 and TiO_2 in a given ratio in air at 1,200° C. for several hours. We then synthesized four specimens of the $TiO_2.Fe_2O_3$—$2TiO_2$.FeO solid solution series in the same way, changing the proportions of TiO_2, Fe_2O_3 and Fe gradually.

The chemical composition of the synthetic $TiO_2.Fe_2O_3$—$2TiO_2$.FeO series solid solutions is given in Table 1 and is illustrated on the diagram of the FeO—Fe_2O_3—TiO_2 ternary system shown in Fig. 1. Crystallographic analysis of these specimens was carried out by a 'Norelco' X-ray spectrometer. In the spectrograms, no trace of the ilmenite – hæmatite

Table 1

Sample No.	Chemical composition				Crystal parameters				Magnetic susceptibility
	$FeO + Fe_2O_3 + TiO_2$ (wt. per cent)	FeO (mol. per cent)	Fe_2O_3 (mol. per cent)	TiO_2	$FeTi_2O_5$ (mol. per cent)	a (A.)	b (A.)	c (A.)	Volume of unit cell (A.^{3})	
*P*1	100·00	0·00	50·00	50·00	0·0	9·767	9·947	3·717	361·1	43×10^{-6} e.m.u./gm.
*P*2	100·81	10·28	32·41	57·31	26·0	9·787	9·965	3·734	364·2	55×10^{-6}
*P*3	97·28	21·29	20·11	58·60	49·9	9·795	9·987	3·739	365·8	*
*P*4	97·73	24·82	12·93	62·25	65·6	9·800	10·011	3·741	367·0	58×10^{-6}
*P*5	99·80	28·91	6·41	64·68	81·7	9·801	10·031	3·743	368·0	48×10^{-6}
*P*6	83·05	34·33	0·11	65·56	99·9	9·798	10·041	3·741	368·0	53×10^{-6}

* ($\sigma = 2{\cdot}0$ e.m.u./gm. at $H = 2{,}200$ oersteds)

series minerals or of titanium dioxide could be found; but a single phase, the crystal structure of which is very much like that of pseudobrookite, was observed. It has been reported by Pauling that pseudobrookite has an orthorhombic crystal structure[2], while Curnow and Parry considered that their iron–titanate specimen, obtained from the oxidation of ilmenite, was a tetragonal structure. In the present work we conclude from a careful analysis of the X-ray diffraction chart that the crystal structure of the $Fe_2O_3.TiO_2$—$2TiO_2.FeO$ series minerals newly found in the FeO—Fe_2O_3—TiO_2 ternary system must be regarded as orthorhombic (see Table 1). Fig. 2 shows the relation between the volume of a unit cell of the

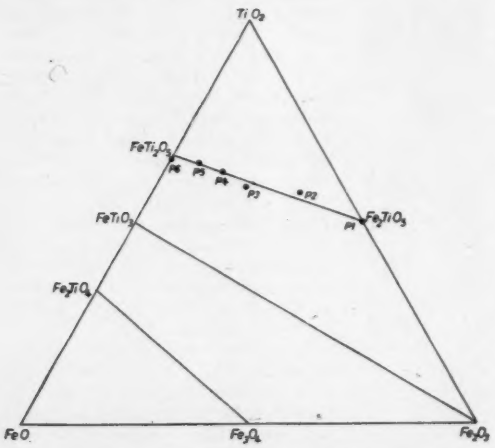

Fig. 1. Chemical composition of Fe_2TiO_5—$FeTi_2O_5$ solid solution series represented on an FeO—Fe_2O_3—TiO_2 ternary system in mol. per cent

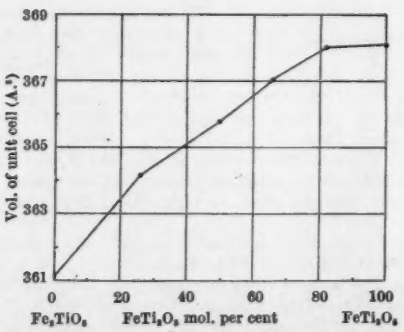

Fig. 2. Relation between the volume of a unit cell of the Fe_2TiO_5—$FeTi_2O_5$ solid solution series and the content of $FeTi_2O_5$

$TiO_2.Fe_2O_3$—$2TiO_2.FeO$ mineral series and the content of $2TiO_2.FeO$. It will be clearly seen from Table 1 and Fig. 2 that as the $2TiO_2.FeO$ content increases in the $Fe_2O_3.TiO_2$—$2TiO_2.FeO$ solid solution series, the crystal parameters become larger, though this increase is small.

Measurement of magnetization curves of all the synthetic specimens up to about 2,500 oersteds was carried out by means of a magnetic balance. It was found that these synthetic $Fe_2O_3.TiO_2$—$2TiO_2.FeO$ series specimens, except *P*3, have paramagnetic properties at atmospheric temperature, that is, the magnetization increases almost proportionally to the field intensity. The values of magnetic susceptibilities of these paramagnetic specimens are given in Table 1. As for specimen *P*3, it shows a ferromagnetic character in the magnetic measurement, although its intensity of magnetization is very weak, the Curie points determined from measurement of the thermomagnetic curve being about 220° and 540° C. This feeble ferromagnetism may be due to contamination with a very small amount of ferromagnetic ilmenite or titanomagnetite which could not be distinguished by the X-ray analysis.

From these experimental results, it can be said that there exists a new orthorhombic solid solution connecting $Fe_2O_3.TiO_2$ and $2TiO_2.FeO$ in the FeO—Fe_2O_3—TiO_2 ternary system. This new phase must therefore be considered in studying the natural ferromagnetic minerals, especially in interpreting oxidation products of the ilmenite – hæmatite series minerals or of the titanomagnetites.

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Effect of Gaseous Impurities on the First Townsend Coefficient in Hydrogen

Several experimental determinations of α/p_0 (ionizations/cm./mm. mercury at 0° C.) as a function of E/p_0 (volts/cm./mm. mercury at 0° C.) have been made recently[1–4] in hydrogen under conditions of uniform static electric fields. These recent determinations agree to better than 10 per cent over the range $23 < E/p_0 < 40$, but they diverge quite considerably from earlier measurements in the same range of E/p_0 by both Ayres[5] and Hale[6]. At larger values of E/p_0 (> 40) the only recent measurements which have been published are those of Rose[1]. These agree well

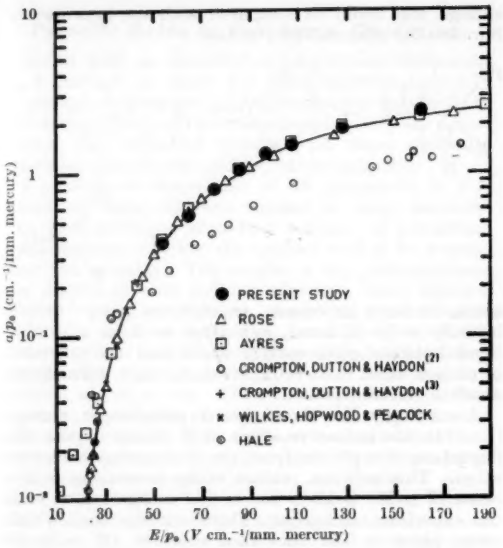

Fig. 1

with the corresponding values of Ayres, but still show poor agreement with the values obtained by Hale.

In view of this disagreement, we feel that some measurements for $E/p_0 > 50$, which have been made in this laboratory as a preliminary to the main investigation of the effect of transverse magnetic fields on the value of α/p_0, should be more widely known. They are shown for comparison with the measurements of Rose and Ayres in Fig. 1, the agreement between these various measurements being within 10 per cent for the whole range of $50 < E/p_0 < 190$. This is important because, whereas Rose[7] took great care to eliminate gaseous impurities from his very pure gas samples, we took no special precautions to achieve high purity. Although the hydrogen was admitted through a palladium thimble, the ionization chamber was not baked out and the lowest pressure obtainable in the vacuum system was about 10^{-3} mm. mercury. In common with all the recent determinations[1-4], however, mercury vapour was not present, pressure measurements being made with an oil manometer and thermocouple gauge. Furthermore, values of α/p_0 measured with and without the use of a refrigerated trap showed no significant difference.

It seems clear, therefore, with our independent confirmation of the values obtained by Rose, under quite different conditions of gas purity, that for values of E/p_0 greater than 50 the effect of small amounts of the common gaseous impurities (for example, oxygen, water, carbon dioxide, nitrogen, mercury) is not so important in hydrogen as was indicated by previous measurements[8].

It would be expected, however, that the effect of an impurity gas of ionization potential (V_I) less than that of hydrogen (V_H) would become more important at lower values of E/p_0 and would lead to an increase in the value of α/p_0. This is because the ratio of the number of electrons with energy greater than V_I to the number of electrons with energy greater than V_H increases with decreasing E/p_0. This interpretation appears to be substantiated by the nature of the large divergence of Ayres's values from those of the recent determinations at low E/p_0. Further, owing to the presence of mercury in Ayres's work and its meticulous exclusion from the later experiments, one would expect the important impurity to be mercury vapour. This conclusion, however, is not entirely justified, as a comparison of similar measurements of α/p_0 in nitrogen, made independently by Ayres[5], Posin[8] and Masch[9], will show. In this case, although all three determinations at low E/p_0 were made with gas contaminated with mercury, the values obtained by Ayres are again considerably larger than those of either Posin or Masch. Unfortunately, there are no recent measurements of α/p_0 available for comparison at these low values of E/p_0 (less than about 30) in pure mercury-free nitrogen, and the precise influence of impurity gases at low values of E/p_0 remains to be determined. Experiments concerned with such problems are at present in progress in these laboratories.

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An Iridium Plating Solution

During an investigation at this laboratory into the depolarization of oxygen electrodes by carbon monoxide, a vibrating iridium microelectrode was required. The basis of the electrode was a steel wire and, for mechanical reasons, some form of iridium plating was necessary. The plating solution detailed below gives a dark grey coherent deposit of iridium when used under the conditions stated. The resultant deposit behaves in a manner characteristic of the metal[1] and is satisfactory for electrochemical work.

The solution consists of ammonium fluoride (1·4 gm.), ammonium borate (0·6 gm.) and iridium chloride (1 gm.) dissolved in water (100 ml.). Ethanol (0·5 ml.) is added and the solution boiled gently until the smell of ethanol is no longer detectable. After filtering, concentrated ammonia (0·1 ml.) is added and the solution made up to its original volume (100 ml.).

Plating is carried out at room temperature at a current density of 20 m.amp.cm.$^{-2}$, the work being made the cathode.

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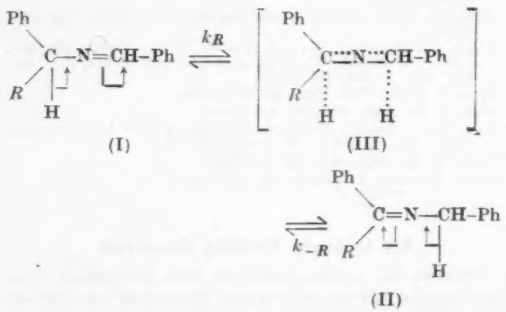
Influence of Alkyl Groups in the Prototropic Change in Methyleneazomethines

Arguments for and against control by either polar or steric effects of the course and rate of substitution and elimination reactions have recently been given[1–3]. The concept of steric assistance has been specially stressed as an important factor in determining relative rates of unimolecular eliminations of highly branched alkyl compounds[3,4]; in contrast to this positive steric factor, negative steric effects (connected with classical steric hindrance) play an important part in bimolecular nucleophilic substitution reactions[5]. It has been suggested[3] that these steric effects can account for the known facts about nucleophilic substitutions and eliminations of alkyl compounds without need of special considerations regarding polar, particularly inductive, effects.

In connexion with these arguments, we should like to put forward some results, obtained in our laboratories, which, we think, bear on the question of the relative importance of steric and polar effects in heterolytic reactions.

Our work deals with the mechanism of prototropic change in methyleneazomethines; this is a base-catalysed synchronous S_E2' reaction[6]. The effect of alkyl groups on rate has now been examined[7–10]. The system under study is:



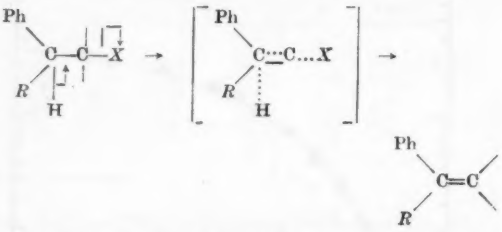
in which R = H, Me, Et, Pr^i, Bu^t. Reactions have been conducted under the conditions stated in Table 1, where specific first-order rate-constants are given. Alkyl derivatives have been studied by the method of loss of optical activity starting with the optically active compound (I)[7], and by spectroscopic estimation of mixtures of isomeric azomethines starting with pure (I) or (II)[8]. The prototropic change in benzylidenebenzylamine (I = II, R = H) has been followed by isotopic tracer technique using azomethine labelled with carbon-14[10].

Table 1. Specific Rate-constants (k in hr.$^{-1}$) for the Prototropic Changes of Methyleneazomethines in 1·3 *N* Sodium Ethoxide in Ethyl Alcohol (60 per cent) -dioxan (40 per cent) at 50°. Concentration of Azomethine, 0·4 *M*

R	k_R	k_{-R}
H	1·7	1·7
Me	0·132	0·096
Et	0·0112	0·0091
Pr^i	0·0059	0·0046
Bu^t	0·0034	0·0023

It can be seen that the result of introducing alkyl groups either in the carbon atom from which a proton departs, or in the one attacked by a proton, is to lower reaction-rate.

Now, if the removal of a proton by a base is considered as the important process in the prototropic change, this could be compared with the appropriate bimolecular elimination reaction:



since, in both processes, an electron pair, forming initially a C—H bond, is shifted to form a double bond between that carbon atom and the nitrogen or carbon atom next to it, which, in turn, gives away another electron pair.

Accordingly, in the forward prototropic change (I → II), the inductive effect of R should oppose the departure of a proton from the R-substituted carbon atom. This will give values of k_R decreasing in the order H > Me > Et > Pr^i > Bu^t in agreement with the experimental results. The electronic shift which takes place in the backward reaction (II → I), as shown in (II), will be also opposed by inductive release from R, giving again a sequence of k_{-R} corresponding to that found experimentally.

On the other hand, hyperconjugation arising in the transition state of the forward reaction cannot be made responsible for the sequence of rates; since, if it were responsible, alkyl derivatives should react more quickly than benzylidenebenzylamine. In the backward reaction hyperconjugative control fails also to account for the experimental results, since it would give the minimum rate to the more hyperconjugated methyl-substituted (II). Small contributions due to hyperconjugation are considered, as will be shown in more detail elsewhere[10].

Steric assistance seems to play no important part in these reactions; because, in the forward reaction, in which R is systematically changed at the proton-departing carbon atom, the sequence of rates would be opposite to that experimentally found. This could, of course, be presumed on account of the small size of the group leaving.

It can be concluded that alkyl substituents, introduced at the proton-departing or at the proton-attacked carbon atoms in these prototropic changes, exert Hofmann-type influences, which can be accounted for by inductive control.

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Pyrrolic Acids in Porphyrin Oxidation

Acids such as 4-methyl-2,3,5-pyrroletricarboxylic (I), 4-methyl-3-ethyl-2,5-pyrroledicarboxylic (II), 4-methyl-3-propionic-2,5-pyrroledicarboxylic (III), and 4-ethyl-2,3,5-pyrroletricarboxylic (IV) are found among the oxidation products of some naturally occurring porphyrins and dihydroporphyrins.

A solution or suspension of the porphyrin in 2 *N* potassium carbonate was treated at room temperature with sufficient saturated solution of potassium permanganate to allow the oxidant still to be present after ten minutes. The excess of the permanganate was destroyed with sodium sulphite. After filtering off the manganese dioxide, the solution was cooled to 10° C., acidified with concentrated hydrochloric acid (congo red as indicator), filtered again if necessary and finally freed from oxalic acid with calcium chloride at *p*H 4·5–5. Then the clear solution, thus obtained, was made strongly acid with concentrated hydrochloric acid. This solution was extracted four times with peroxide-free ether, and after evaporation to dryness the residue was treated with a small amount of distilled water and filtered. The filtrate was submitted to chromatographic analysis on Whatman No. 1 paper and compared with samples of synthetic pyrrolic acids. The solvents used were: *n*-butyl alcohol/acetic acid/water (4 : 1 : 5); ethyl alcohol / 33 per cent ammonia / water (20 : 1 : 4); *n*-butyl alcohol / 2*N* ammonia (1 : 1). The pyrrolic acids were easily detected by spraying the paper first with diazotized sulphanilic acid and then with a dilute sodium hydroxide solution. The amount of porphyrin required is 5–20 mgm.

Table 1 shows the compounds oxidized and the acids obtained.

Table 1

Compounds oxidized	Acids obtained I	II	III	IV
Protoporphyrin IX	+		+	
Hæmin	+		+	
Mesoporphyrin IX		+	+	
Phæophorbide *a*	+	+	+	
Mesophæophorbide *a*	+	+	+	
Phæoporphyrin a_5	+	+	+	
Phæophorbide *b*	+		+	+
Phæophytin *a* + *b*	+	+	(+)	+

With the exception of the vinyl and formyl groups oxidized to carboxyl groups, the other side-chains are found to be unchanged, and this provides us with a useful method for investigating the nature of the substitution groups 1 to 8 (H. Fischer system of nomenclature) of a porphyrin.

The occurrence of these acids is, moreover, a chemical indication that the porphyrin system must be considered a resonance hybrid of tautomeric forms.

Acid (III) cannot be detected after the oxidation of phæophytin *a* + *b*, until after the degradation mixture has been hydrolysed. This means that acid (III), after the oxidation process, is still linked to the phytilic residue. This is therefore a clear proof of the phytol position in chlorophyll *a* and in chlorophyll *b*.

The presence of acid (III) in the oxidation products of phæophorbide *a* and mesophæophorbide *a* is difficult to understand because the ring from which our acid (III) is formed has a pyrrolinic structure and is, according to H. Fischer, very difficult to dehydrogenate by oxidative degradation. Furthermore, from a quantitative point of view, it seems that, starting from mesophæophorbide *a* and phæoporphyrin *a*, comparable yields of acid (III) are obtained.

These results have prompted us to undertake investigations on dihydroporphyrins to establish the position of the two hydrogen atoms. A full account of the present work will appear in the *Annali di Chimica*.

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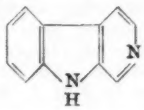
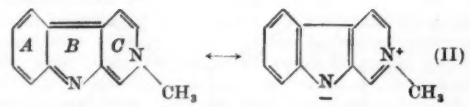
Structure of Anhydronium Bases

During recent years, a number of authors[1–5] have attributed to several alkaloids containing the β-carboline system,



the structure of anhydronium bases; for example, Schwarz[4] suggests:



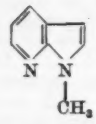
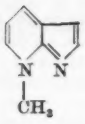
following the formulation first introduced by Armit and Robinson[6] in 1925, who described an analogous derivative of the α-carboline.

However, it appears to us unnecessary to write a formula bearing separated charges, because the covalent formula might rightly account for the chemical and physical properties of the anhydronium bases, provided due attention is given to the valence state of the nitrogen atoms in these molecules.

The main characters of anhydronium bases appear to be: (i) a pyridine-like nitrogen on ring *B* (formula I), that is, a nitrogen in the valence state s^2xyz, V_3 (or, as reported in some examples given by Armit and Robinson[6], a carbon atom in its trigonal state); (ii) an amino-like nitrogen on ring *C*, that is, a nitrogen in the valence state sx^2yz, V_3. It follows that the anhydronium bases are characterized by two hetero-aromatic condensed rings, one with five and the other with seven conjugated π-electrons, built up with the contribution of the nitrogen *p* and lone pair electrons respectively, constituting a system clearly related to azulene.

The passage from the carbolines to the corresponding anhydronium bases recalls in fact that from naphthalene to azulene. The main features of this change are the spectral bathochromic shift, the appearance of a dipole moment and a marked increase in the strength of the base. All the anhydronium bases are reported to be yellow to deeply red substances, whereas the corresponding carbolines are colourless[3]; they are very strong bases[7], their basicity depending on the mutual position of the two nitrogen atoms[7]. Also, a dipole moment of about 8 D. has been reported for sempervirine[8].

The best way of testing the above assumptions seemed to us to be to calculate the charge distribution, dipole moment and spectral shift for a simple molecule possessing only the fundamental conjugated system of the anhydronium bases, represented by rings *B* and *C*. We chose, therefore, as a model the compounds (III) and (IV), the last of which possesses

(III)   (IV)

the anhydronium base system corresponding to the α-carboline anhydronium base described by Armit and Robinson[6]. Compounds (III) and (IV) have been recently prepared and described by Robison and Robison[8]; the anhydronium base character of (IV) results from its structure, which was proved unambiguously, from the spectral shift and its strong basicity.

Calculations were made following the simplest form of the molecular orbital *LCAO* method with a set of parameters previously employed by Orgel *et al.*[9] for eighteen heterocyclic compounds, a set which seems to reflect fairly adequately the changes in the nitrogen valence states. The calculated molecular diagrams are shown in Figs. 1 and 2.

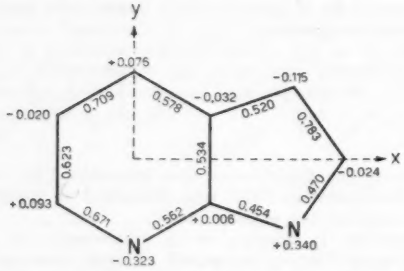


Fig. 1. Molecular diagram of 1.methyl-7.aza-indole

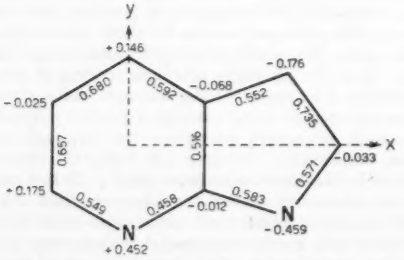


Fig. 2. Molecular diagram of 7.methyl-7H-pyrrole[2,3-b]pyridine

The total dipole moments, using the method of ref. 9, are $\mu(III) = 1{\cdot}25$ D., $\vartheta = 54° 30'$; $\mu(IV) = 6{\cdot}35$ D., $\vartheta = 180°$, directions being taken anti-clockwise to the x-axis and negative → positive. The calculated and observed[6] $\pi \rightarrow \pi^*$ transitions compare reasonably well:

(III): $N \rightarrow V_1 = 1{\cdot}430\ \beta$ calc.; 34,500 cm.$^{-1}$ obs.;
$N \rightarrow V_2 = 1{\cdot}716\ \beta$ calc.; 44,400 cm.$^{-1}$ obs.

(IV): $N \rightarrow V_1 = 1{\cdot}208\ \beta$ calc.; 32,400 cm.$^{-1}$ obs.;
$N \rightarrow V_2 = 1{\cdot}477\ \beta$ calc.; 40,800 cm.$^{-1}$ obs.

the average value for β being 26,000 cm.$^{-1}$; the bathochromic shift of the whole spectrum is correctly accounted for. The calculated $n \rightarrow \pi^*$ transitions, which may be approximated by taking as a zero-point the non-bonding molecular orbital energy-level of the molecules, give for (III) $0{\cdot}700\ \beta'$ and (IV) $0{\cdot}521\ \beta'$. The large band of (IV) at about 26,000 cm.$^{-1}$, which the blue shift in aqueous solvents indicates as $n \rightarrow \pi$, is responsible for the appearance of a yellow colour and corresponds to a band appearing as a shoulder around 30,000 cm.$^{-1}$ in the plots[8] of the spectra of 7-aza indole and its derivatives, which show similar behaviour.

Although a discussion of the molecular diagrams is beyond the scope of this communication, it may be interesting to remark that the partition of the π-electrons among the six- and five-membered rings is about the same in the two compounds[10], namely, $(5{\cdot}2 + 4{\cdot}8)e$ in (III) and $(5{\cdot}3 + 4{\cdot}7)e$ in (IV). The marked change in the polarity of (IV) with respect to (III) results, therefore, from the change of the molecular core as here represented:

that is, from the change of the potential field in which the ten π-electrons move; a conclusion which supports our assumptions about the structure of the anhydronium bases.

Theoretical work is in progress, using the same method, in which the four carbolines and the corresponding anhydronium bases are treated as a system of fourteen electrons, with the view of obtaining a better understanding of their chemical behaviour and spectroscopic properties. These results are expected to provide useful information for the elucidation of the structure of new alkaloids isolated from South American *Strychnos* which are being studied in these laboratories[11].

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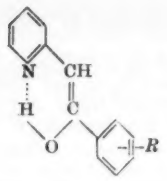
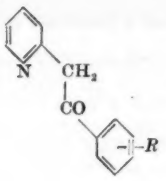
Steric Influences on the Structure of Chelating Agents and on the Stability of Metal Chelates

2-Phenacylpyridine and its derivatives are of interest because of their possible bacteriostatic activity[1] and their power to chelate metals. In addition, it has been shown[2] that in the solid state they exist, with accountable exceptions, in the resonance-stabilized conjugate chelated enol form (I) rather than in the keto form (II). The purpose of this communication is to record some results of a study of their infra-red spectra, and to point out that they provide interesting examples of the influence of steric hindrance on molecular structure and on the stability of metal chelates.



(I)



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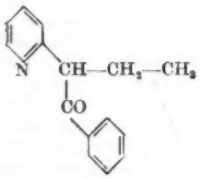

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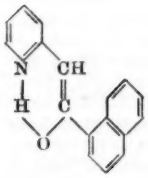
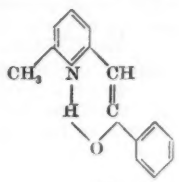


(IV)

When the keto-methylene group of 2-phenacylpyridine (which exists as a yellow solid in the form I, R = H) is substituted by an alkyl group, for example, ethyl, the infra-red spectrum of the resulting colourless compound shows the presence of a carbonyl group, thus showing that it exists in the keto form (III), in spite of the remaining proton being available for enolization. The infra-red evidence is supported by the ultra-violet spectra[1] and by the proton spin resonance spectra (Branch, R. F., Bentley, P. G., and Hamer, A., unpublished work). This increase in thermodynamic stability of the keto form on substitution by an alkyl group is also observed in β-diketones and β-keto-esters, to which the present compounds are analogous. This effect has been attributed to the predominance of the inductive effect over the effect of hyperconjugation in these cases where the double bond of the enol form is conjugated with another unsaturated linkage[3]. Although this will be a contributing factor, it is now suggested that the stability of the keto form in this case is due, in the main, to the prevention of the attainment of uniplanarity in the enol form, with consequent loss of resonance stabilization, by steric hindrance between the alkyl group and the benzene ring hydrogen atoms. However, the infra-red spectrum of α-(1′-naphthoyl)-2-methylpyridine (IV) shows that it exists in the conjugate chelated enol form although a similar steric hindrance to uniplanarity would be expected in this compound. It is probable that the greater resonance energy of the naphthalene ring causes the steric effect to be less important in this case. (It should be noted, however, that naphthalene compounds have been observed to show anomalous behaviour where steric considerations are concerned. Thus, it has been shown[4] that optically active 1 : 1′-dinaphthyl derivatives racemize even when mechanical interpretations of a molecular model indicate this to be impossible.)

When the keto-methylene group in 2-phenacylpyridine is substituted by a benzoyl group, it might be expected that steric hindrance to uniplanarity would be greater than with an alkyl group, and hence enolization suppressed. However, enolization does occur[1]; but it should be observed that the benzoyl group is a 'slimmer' group than methyl or ethyl, and co-planarity of the benzene ring, the chelate ring (involving nitrogen) and the pyridine ring can be attained with the benzoyl group lying at right angles to this plane. The alternative mode of chelation in which the enolic OH group is in the position *trans* to the pyridine ring and hydrogen-bonded to the remaining carbonyl group is less probable on energetic grounds, since this structure would contain three non-parallel, non-coplanar aromatic rings. The relatively low solubility of hydroxy-pyridine derivatives has been ascribed to powerful hydrogen bonding between the pyridine nitrogen atom and the OH group[5], and this fact also suggests that chelation of OH to the pyridine nitrogen atom would be preferred in the present case. The suggested structure is supported by the fact that the aroyl derivatives —CO—C_6H_5, —CO—$C_6H_4NO_2$-*p*, —CO—C_6H_3Cl-*p* and —CO—$C_6H_3(NO_2)_2$1 : 3 : 5 all show an ultra-violet peak in the same position[1,6] at 370 mμ. Since the varying substituents lie outside the 'resonance plane', they will not be conjugated with the π-electron system in the plane. It is interesting to note that aroylation of 2-phenacylpyridine with *p*-chlorobenzoyl chloride gives the same yellow compound as when 2-*p*-chlorophenacylpyridine is aroylated with benzoic anhydride[6]. This indicates that the compound with the chlorine atom in the 'vertical' ring is the stable one.

It is interesting to compare the structure of these compounds as revealed by their infra-red spectra with their known sensitivity towards metal ions[1]. Although other factors, such as solubility, influence these sensitivities, they are also dependent upon the stability of the metal chelate. 6-Methyl-2-phenacylpyridine (V) shows no tendency to chelate copper, ferrous or ferric iron or cobalt, in spite of the fact that the infra-red spectrum shows that it exists in the conjugate chelated enol form. This is due to the prevention of complex formation by steric hindrance involving the methyl group. This effect is analogous to the effect observed in 2-methyloxine, which fails to precipitate aluminium[7]. The steric effect in the present example is more severe than in 2-methyloxine since the methyl group is more closely directed towards the metal-ligand bonds. This is readily seen by comparing the ions of the methyl derivatives of oxine (VI) and 2-phenacylpyridine (VII). In the case of a planar, divalent chelate of 6-methyl-2-phenacylpyridine, there is an additional steric hindrance since the methyl group in one ligand tends to force the benzene ring of the opposite ligand to lie out of the plane of the rest of the molecule, thus causing loss of resonance stabilization. Another



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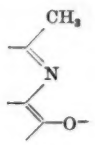

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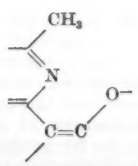

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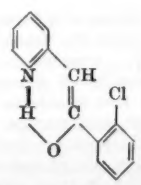

(VIII)

example of steric hindrance to uniplanarity is given by 2-*o*-chlorophenacylpyridine (VIII), which shows only a slight tendency to chelation. This is due to steric hindrance, whereby the benzene ring containing the chlorine atom is forced to lie outside the plane of the rest of the molecule because of an 'ortho effect'.

It is suggested that these steric effects, in addition to the usual electronic effects of the substituents, will affect the stability of these chelates, but a final evaluation must await the determination of the stability constants.

The infra-red spectra, the ultra-violet spectra and the nuclear magnetic resonance spectra of these compounds and their partially deuterated derivatives will be published elsewhere. Thanks are due to Drs. A. H. Beckett and K. A. Kerridge, of the School of Pharmacy, Chelsea Polytechnic, for providing the samples.

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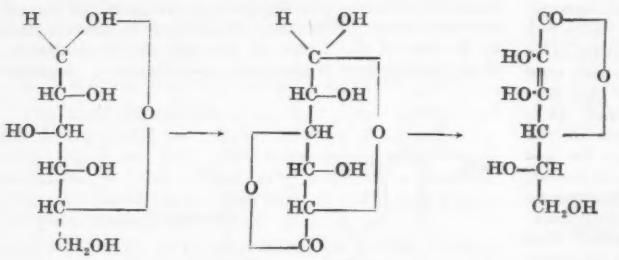
Glucuronic Acid, a Precursor of Ascorbic Acid in *Aspergillus niger*

The isotopic work of Jackel, Mosbach, Burns and King[1] with rats, and that of Sivarama Sastry and Sarma[2] with plants, showed definitely that in both these species, glucose is the direct precursor of L-ascorbic acid. The studies of Horowitz and King[3] and Isherwood, Chen and Mapson[4] have established that in both cases glucuronic acid is an intermediate in the conversion of glucose to ascorbic acid, which takes place according to the sequence :



Little is known, however, concerning the mechanism involved in the synthesis of ascorbic acid by *Aspergilli*. Geiger-Huber and Galli[5] reported that certain strains of *Aspergillus* produced ascorbic acid and that this synthesis was maximal in presence of 15–20 per cent sugars in the medium at *p*H 2·25. Glucuronic acid is also known to be produced, and Butkevitch, Menshinskaja and Trofimova[6] have suggested that it may arise from 2-ketogluconic acid. It was of interest, therefore, to see whether glucuronic acid was a precursor of ascorbic acid in *Aspergillus niger*.

The organism employed in these investigations was a strain of *A. niger*, obtained from the National Collection of Type Cultures, Poona, India, and maintained by weekly transfers in this laboratory. Preliminary trials showed that this strain synthesized ascorbic acid to the maximum extent after 10 days when grown at *p*H 2·5–3·0. The medium employed[7] had the following composition, per 100 ml. : sucrose, 15 gm. ; ammonium nitrate, 250 mgm. ; dihydrogen potassium phosphate, 250 mgm. ; crystalline magnesium sulphate, 250 mgm. ; crystalline manganese sulphate, 100 mgm. ; and crystalline zinc sulphate, 0·0125 mgm. 10 ml. of the above medium adjusted to *p*H 2·5–3·0 was taken in 50-ml. 'Pyrex' flasks and *A. niger* grown for 10 days. Glucuronic acid was added as its lactone, D-glucurone, in suitable amounts as shown in Table 1. At the end of the growth period, the weight of the dried mycelia from each flask, as well as total acid and ascorbic acid produced, were estimated, the total acid by titration against *N*/20 sodium hydroxide using bromthymol blue as the indicator, and the vitamin by indophenol titration as in earlier studies[2,7]. The results are presented in Table 1.

Table 1. Influence of Glucurone on Growth and Ascorbic Acid Synthesis by *Aspergillus niger*.
(10 days growth on 10 ml. medium ; *p*H 2·5–3·0)

No.	Glucurone level (mgm. per ml. medium)	Mycelial growth (mgm. of mat per flask)	Total acid (= c.c. *N*/20 NaOH per ml. medium)	Ascorbic acid (mgm./ 100 ml. medium)
1	Nil	212·5	27·80	4·05
2	2·0	232·0	22·70	11·05
3	3·0	240·0	18·00	11·75
4	5·0	251·0	20·00	13·20

It may be seen from the data that D-glucurono-γ-lactone stimulates growth but not acid production. There is, however, no correlation between total acid and ascorbic acid under these conditions, which is in agreement with observations made earlier[5]. The synthesis of ascorbic acid is, however, significantly enhanced, showing that *A. niger* can utilize glucurone for this purpose ; and, if the increase in ascorbic acid over the control, that is, without glucurone, is considered, it can be seen that at the levels of glucurone employed, the conversion from glucurone is between 1·8–3·5 per cent. The lower conversions at the higher levels of glucurone may possibly be a reflexion of increased utilization of the ascorbic acid synthesized, due to the greater growth of the organism as evinced by mat weights. Thus these values are only approximately indicative of the magnitude of the conversion, but nevertheless they serve to show that this is of the same order as in plants and animals.

Further, if glucuronic acid arises from 2-ketogluconate as suggested by Butkevitch *et al.*[6], since 2-ketogluconic acid is itself a product of glucose metabolism in *A. niger*[8], it becomes obvious that in this organism also the sequence

glucose → glucuronic acid → ascorbic acid

represents the biosynthetic pathway involved in ascorbic acid formation. The occurrence of this sequence in such varied species as fungi, plants and

rats emphasizes the fundamental importance of this series of reactions in Nature.

Our thanks are due to the University of Madras for permission to publish the above results, which form part of a thesis for which one of us (K. S. S.) was awarded the M.Sc. degree.

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Photosensitivity of the Iron (III) Ethylenediamine Tetraacetate Complex

In 1952, Jones and Long[1] observed that the iron (III) ethylenediamine tetraacetate complex is photosensitive. Hill-Cottingham[2] also noted the photochemical dissociation of this complex, which he applied for qualitative work in his investigation of the photochemical dissociation of iron (III) chelates by the action of daylight. Weinstein, Robbins and Perkins[3] examined this complex at *p*H 7; they remarked that it is more stable than other metal ethylenediamine tetraacetate complexes over a wide *p*H region. They suggested that it is metabolized in the plant. Heath and Clark have studied the iron supply of plants by using this complex[4].

There are several methods for the quantitative determination of iron by the ethylenediamine tetraacetate complex: two volumetric ones[5,6] for 0·1 *N* and 0·01 *N* solutions, and also two spectrophotometrical ones (one for amounts of 4–500 mgm. iron per litre at 366 mμ[7] and one for amounts of 0·5–12 mgm. iron per litre at 260 mμ[8]). The latter was used for our experiments. However, we found that this determination is carried out preferably at *p*H 3–6, instead of 1–3 as suggested by Uzumasa and Nishimura[8]. The dissociation is then less pronounced.

In connexion with the photochemical dissociation of the complex, we find that: (1) Dissociation depends upon the prevailing daylight intensity; in the dark no dissociation takes place. (2) Dissociation is pronounced when the excess ethylenediamine tetraacetate is small and also at low *p*H values; dissociation is low at high *p*H and large excess of ethylenediamine tetraacetate. The influence of the *p*H is shown by Table 1. Table 2 shows the influence

Table 1. Concentration of iron, $3{\cdot}96 \times 10^{-5}$ *N*; concentration of ethylenediamine tetraacetate, 8×10^{-5} *N*. These solutions, kept in the dark, showed after 0·5 hr. and even after one day extinctions of 0·367 at 260 mμ in 1-cm. quartz cells

*p*H	Extinction after 0·5 hr.	Extinction after 1 day
2·61	0·363	0·216
1·76	0·357	0·188
1·65	0·355	0·164
1·57	0·374	0·146
1·44	0·358	0·124

Table 2. Concentration of iron, $4{\cdot}12 \times 10^{-5}$ *N*. *p*H 4·56. Extinction without dissociation 0·373 measured at 260 mμ in a 1-cm. quartz cell

Ethylenediamine tetraacetate concentration	Extinction after 0·5 hr.	Extinction after 1 day
$4{\cdot}12 \times 10^{-5}$	0·340	0·329
4·33	0·342	0·330
4·94	0·370	0·348

of the concentration of ethylenediamine tetraacetate. (3) Regeneration as found by Jones and Long[1] is possible and very pronounced when ethylenediamine tetraacetate is present in excess. An extinction of 0·362 was observed for an iron solution (concentration $3{\cdot}96 \times 10^{-5}$ *N*; *p*H 1·59) with a 25-fold excess of ethylenediamine tetraacetate and a light path of 1 cm. at 260 mμ in the undissociated condition. By exposing the solution for 24 hr. at a window, the extinction decreased to 0·270.

After keeping this solution for two days in the dark, the extinction increased to 0·358. Then the solution was exposed to light at a window again, this time for three days, and the extinction became 0·311. Finally, the solution was kept in the dark for one day, and the extinction increased to 0·342.

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A Crystalline Substance isolated from Egg Yolk which promotes Growth of a Minute Inoculum of Human Tubercle Bacilli

Egg yolk is the chief component of the solid culture media which are currently employed for the clinical detection of tubercle bacilli[1]. But these egg media coagulate during their sterilization treatment and cannot liquefy again once they are so treated. This property is an essential defect in laboratory practice compared with ordinary agar solid media. So I have attempted to find the growth-supporting substance from a minute inoculum of the bacilli in the egg yolk and to add it to the agar medium which could be used as a routine agar medium for the tubercle bacilli. This substance was isolated in the crystalline form and a simple synthetic solid medium was devised which contained a small amount of it and 'Tween 80' as a carbon source[2]. This in minute amounts supported the growth of human tubercle bacilli. This communication deals with the method of isolating the crystalline substance and its principal properties and those of the synthetic agar medium containing it.

'Tween' solution extract of egg yolk was prepared by autoclaving 10 per cent yolk suspension in 6 per cent 'Tween 80' solution in water at 120° C. for 15 min. The transparent 'Tween' extract of the yolk was

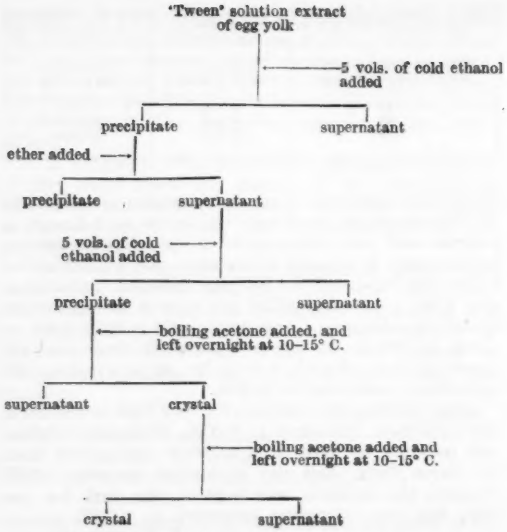

Fig. 1. Purification process of the active crystal

purified as shown in Fig. 1. The entire purification process was performed at 10–15° C. The yield of the crystalline substance was about 1 per cent of the initial yolk. The crystals present a rosette form (Fig. 2). The melting point of this substance is 35–36° C. It contains no nitrogen or phosphorus, and is very soluble in chloroform and ether, but scarcely soluble in acetone or ethyl alcohol at 10° C., and insoluble in water at all temperatures. Its activity is very stable to heat and this renders it fit for autoclaving of the synthetic agar medium containing it.

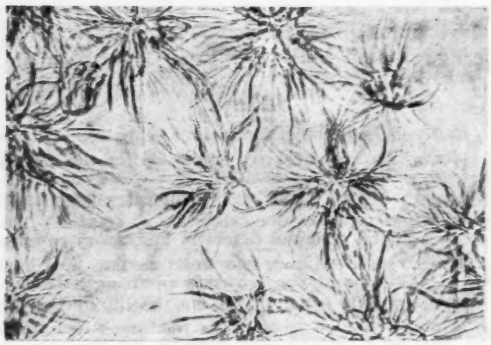

Fig. 2. Crystals of the active principle

The composition of this synthetic medium is as follows:

$Na_2HPO_4.12H_2O$	6·0 gm.
KH_2PO_4	3·0 gm.
Ferric ammonium citrate	0·1 gm.
Glutamate	5·0 gm.
Asparagine	0·5 gm.
$(NH_4)_2SO_4$	0·5 gm.
Calcium pantothenate	0·1 gm.
'Tween 80'	5·0 gm.
* Crystalline substance	0·1 gm.
2 per cent malachite green solution	0·7 ml.
Defatted purified agar (ref. 3)	10·0 gm.
Distilled water	1,000·0 ml.

* The active crystal was added as an ether solution

The final *p*H of the medium was 6·8 without adjusting. The medium can be sterilized by autoclaving at 120° C. for 20 min. and can be directly employed both for the clinical detection of the bacilli as a slant medium and for the colony count as a plate medium.

Table 1. The Growth Results of Each Medium at the Eleventh Day of Incubation

medium \ inoculum mgm.	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}
Synthetic medium	+++	++	+	4	1
	+++	++	+	5	–
Synthetic medium without crystal	+	+	–	–	–
	+	+	–	–	–
Egg medium	++	+	3	–	–
	++	+	5	–	–

+++, ++, + mean the growth grade which cannot be counted. The numbers indicate colonies at the eleventh day of incubation.

This medium was inoculated with 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8} mgm. of tubercle bacillus *H37Rv* strain in duplicate and incubated at 37° C. for 10 days. The same experiment was performed with egg-coagulated medium (Ogawa's medium, which is a modified form of Lewenstein's medium used in this country). The results of the experiments were compared as shown in Table 1. Table 1 shows earlier growth on the synthetic medium than that on the egg medium, from the minute inoculum of the bacilli. This medium also can be employed as a colony count medium for the tubercle bacilli. Colony counting is possible after 15–20 days incubation at 37° C.

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Influence of Analgesic Amines on Plasma Cholesterol of Rats

Analgesic amines may influence, or be influenced by, the level of thyroid activity, for example, hypothyroid rats compared to normal controls gave enhanced response to 1-(*p-cyclo*hexyloxyphenyl)-*ethylamine* in analgesic assay. While seeking the chemical basis for morphine-like activity, by comparison of the above amine with its inactive analogue, 1-(*p-iso*propyloxyphenyl)ethylamine[1], the possibility was considered whether analgesic amines might interfere in processes that are linked to thyroxine.

Plasma cholesterol of rats (*Sperry and Webb* method[2]) was chosen as a convenient index of interference. Results (Table 1) were equivocal but had features of interest. Both amines usually induced marked lowering of cholesterol-level, but occasionally marked rises occurred. All rats used on any one day reacted in the same manner. The *cyclo*hexyl ether could deplete plasma cholesterol by some 50 per cent within twenty minutes at analgesic dosage (20 mgm./kgm.) and was effective at sub-analgesic dosage

Table 1. Influence of Amines on Total Plasma Cholesterol in Rats

Male Hypothyroid Rats

Drug	Saline	1-(*p-cyclo*hexyloxyphenyl)-ethylamine HCl (20 mgm./kgm.)	1-(*p-iso*propyloxyphenyl)-ethylamine HCl (20 mgm./kgm.)
No pretreatment	56·2 ± 5·9	27·1 ± 6·7*	31·2 ± 5·1
With thyroxine (50 μgm.) 5 min. before dosage	44·7 ± 5·4 †	26·8 ± 5·8	47·2 ± 12·7

Normal Rats

Drug	Dose of ethylamine ♀ : 20 mgm./kgm. ♂ : 10 mgm./kgm.	Saline	1-(*p-cyclo*hexyloxyphenyl)-ethylamine HCl	1-(*p-iso*propyloxyphenyl)-ethylamine HCl	Morphine HCl 10 mgm./kgm.
No pretreatment	♀	28·6 ± 2·7	15·7 ± 4·1 or 40·9 ± 9·4	19·6 ± 5·6 or 33·1 ± 1·4	37·5 ± 7·2
	♂	31·6 ± 3·4	23·2 ± 4·0	29·8 ± 5·8	34·8 ± 7·2
With thyroxine (50 μgm.) 5 min. before dosage	♀	27·0 ± 4·1	26·6 ± 1·5	33·8 ± 5·0	24·6 ± 5·0
	♂	—	21·4 ± 3·7	24·4 ± 1·6	21·7 ± 1·9
With analgesic antagonist	♀	—	22·3 ± 4·9‡	—	—
	♂	—	—	—	29·0 ± 2·5§

Drugs given intraperitoneally to groups of 5–8 rats. Blood taken into heparin from the heart under ether anæsthesia. Hypothyroidism induced by thiouracil in drinking water. Survival time 2 hr. Figures express mgm. cholesterol/100 ml. plasma.
* 32·3 mgm./100 ml. found at 20 min. survival. † Normal rats without drugs had 44·7 ± 3·0 mgm./100 ml.
‡ *N*-Allyl-1-(*p-cyclo*hexyloxyphenyl)ethylamine (20 mgm./kgm.) 24 hr. before dosage. § Nalorphine (10 mgm./kgm.) 5 min. before dosage.

(10 mgm./kgm.). Plasma cholesterol-level is not influenced much by most drugs; for example, pentobarbital and amphetamine in the present series. A pronounced fall in normal but not in thyroidectomized guinea pigs has been described for adrenaline[2].

Thyroxine, usually considered to be slow in action, had a prompt effect in preventing depletion, though not where the *cyclo*hexyl ether was given to hypothyroid animals. *N*-Allyl-1-(*p-cyclo*hexyloxyphenyl)-ethylamine, an analgesic antagonist, also significantly reduced the degree of depletion ($P = 0{\cdot}05$). Morphine induced small increases in plasma cholesterol, also noted in dogs[4], but if thyroxine or nalorphine were given beforehand, slight falls were found. All these changes were associated with a small rise in hæmatocrit. The *cyclo*hexyl ether had no influence on cholesterol of brain, or on the ratio of esterified to free cholesterol in plasma. It failed to release thyroxine in two rabbits (I am indebted to Dr. K. Brown-Grant for this result) and there was no evidence for discharge of adrenaline from the adrenals of rats[1].

It is difficult to relate these results to analgesia, but there is a common thread in relation to temperature regulation. Both amines, like morphine, reduced the body temperature of rats[1]. Structures serving temperature and pain sense are *in close anatomical* juxtaposition, and physiological interaction is not improbable. The observed uncertainty in direction of *response suggests* a derangement in mechanisms controlling plasma cholesterol-level. These may be linked to temperature regulation, *for uncertainty in* direction of change of cholesterol-level is found in acute fevers. Artificial lowering or raising of body *temperature influences* the level slightly. Thyroid activity is markedly influenced by the rate of heat loss from the body.

The probability of a complex interrelationship between these various factors has an added interest *in that* eight of at least ten distinct actions of morphine in the body seem peculiarly fitted for maintenance of the hibernating state, *a state initiated by* failure of temperature control during increased rate of loss of body heat. It seems not improbable that morphine-like activity may be a reflexion of an undefined neurohumoral activity.

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Cholesterol Synthesis by Isolated Rat Liver Cells

The losses of metabolic activity in isolated liver cells reported by Laws[1] and others might correlate with results we have obtained in studies of lipogenesis by such preparations. Our cell suspension procedure was essentially a combination of that of Anderson[2] and of Kaltenbach[3]. Rat liver was perfused, and back-perfused with 0·0138 *M* potassium citrate in 0·1 *M* potassium phosphate buffer, *p*H 7·8. In some experiments one or more lobes of the liver were first tied off and the remainder of the organ perfused. After treatment the liver was cut into chunks and *pressed through a 30-mesh stainless* steel screen, 3 cm. in diameter, mounted in the end of a cylindrical 'Lucite' press (Fig. 1). The 3-cm. diameter screen is inserted between the screw-cap and the barrel of the

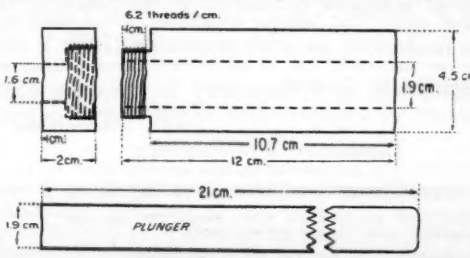

Fig. 1. 'Lucite' tissue press

Table 1. Incorporation of Radioacetate into Cholesterol by Liver Cell Preparations

Type of tissue prep.	No. of experiments	Specific activity of cholesterol†
Unperfused, slice	11	1,334±500
Unperfused, cell suspension	14	5±3
Perfused, slice*	7	344±150
Perfused, cell suspension*	17	3±3
Crude, expressed	4	515±112

* Liver perfused with 0·0138 *M* citrate in 0·1 *M* potassium phosphate buffer, pH 7·8.
† As counts per minute per mgm. cholesterol.

press; the entire assembly may be readily cleaned. All operations were carried out at 0° C.

The expressed tissue is suspended in 0·1 *M* potassium phosphate buffer and the cells washed and isolated as described by Anderson[2]. Cells suspended in Krebs–Ringer phosphate buffer were then incubated either in Warburg flasks, or 20-ml. beakers shaken in a Dubnoff metabolic shaker with 1-carbon-14-sodium acetate. The incubation mixture was: 5 ml. cell suspension (approximately 20 mgm. dry weight tissue) and 0·2 ml. 0·9 per cent 1-carbon-14-sodium acetate, with total activity per flask of $1{\cdot}02 \times 10^7$ counts per min. (windowless flow-gas counter). In some instances portions of the tied-off lobes as well as the perfused lobes were sliced (Stadie–Riggs slicer) and the slices incubated as above for comparison with the cell suspension systems.

After incubation the cholesterol-containing fraction was isolated in the usual way by alkaline hydrolysis, ether extraction and eventual precipitation with digitonin.

From the results in Table 1 it appears that liver cell suspensions, prepared by pressing perfused or unperfused liver through wire screens, evidence a loss in ability to incorporate radioacetate into cholesterol. Furthermore, perfusion of itself may effect the same result with liver slices, to a lesser extent. This latter result may be due to a state of partial disaggregation of the liver cells as a result of citrate perfusion, so that with a perfused slice we may be dealing to some extent with a 'solid mat' of isolated cells. Addition of coenzyme *A*, reduced diphosphopyridine nucleotide or adenosine triphosphate to a perfused cell suspension system did not result in a return of acetate-incorporating activity. If the crude preparation expressed from the 'Lucite' press is incubated without separation of the cells, incorporation of acetate into cholesterol is retained, as indicated in Table 1 (crude, expressed preparation). The activity evidenced here is most probably due to the portion of this crude preparation which is essentially a homogenate. Two of the possibilities explaining these results are that some essential component of the systems studied is lost during perfusion and isolation or that the cell surface is altered in permeability either by loss of adherent ground substance or removal of the proximity of other cells. The second possibility is bolstered by the results with the crude preparation (Table 1) and by the successful use of cell-cluster preparations, as described by Curran[4].

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Incorporation of Ethylene into Fruits

Ethylene, a unique constituent in the emanations of many plants and fruits, is known to be related to the physiological responses of many harvested fruits and vegetables[1]. The presence of ethylene in extremely low concentration in the atmosphere surrounding immature fruits accelerates the onset of the climacteric in most fruits by some mechanism as yet unknown. While ethylene production in fruits may be correlated in many cases with the climacteric rise in their production of carbon dioxide[2], it is still not clear whether ethylene induces the climacteric rise in the nature of autostimulation or, as suggested by Biale *et al.*[3], ethylene is merely a by-product of fruits at a certain stage of maturity.

Therefore, it appears that tracing the biosynthetic pathway of ethylene in plants may help to explain the biological function of this compound. Hall[3] has studied the effect of different substrates upon the production of ethylene from crude extracts of apple juice and *Penicillium digitatum* and postulated that ethylene arises by enzymatic degradation of a number of precursors including arabinose, ethanol, pectin, pectic acid, pyruvic acid, fructose and galactose. However, the validity of this work is impaired by the lack of specificity in the method used for the estimation of ethylene[3].

Because of the limitations derived from dilution factors inherent in the extremely low rate of ethylene production, for example, a maximum of 0·28 ml./kgm. hr. reported for pears[4], and by the fact that the specific precursor of ethylene is unknown, attempts using test substrates, ordinary or carbon-14-labelled, to intact fruits failed to give conclusive results. Consequently, experiments were carried out in which carbon-14-labelled ethylene was introduced in the atmosphere surrounding the fruit in an attempt to study: (1) whether ethylene is a normal metabolic intermediate, in fruit; (2) and, if not, whether ethylene can be incorporated into fruit constituents by way of exchange reactions related to the biosynthetic scheme of ethylene.

Ripe avocado or green pear fruits in large vacuum desiccators were exposed to 0·2 mc. portions of 1,2 carbon-14-labelled ethylene gas (sp. act. $1{\cdot}4 \times 10^6$ c.p.m./mole) in concentrations of 1 part of ethylene to 1,000 parts of air over periods of several days. Each desiccator was equipped with a beaker of potassium hydroxide solution to absorb the respiratory carbon dioxide. Periodically, the oxygen taken up by the fruits, as indicated by an attached manometer, was replaced with oxygen gas from a cylinder.

At the end of the experiment, the radioactive ethylene was swept from the desiccators and trapped in mercuric perchlorate solution[5] and the respiratory carbon dioxide recovered from the trap solution as barium carbonate. The fruits were then mechanically separated into portions (seed, pulp and peel), and each section was treated separately in order to ascertain the distribution of radioactivity in the fruit. The results from two such experiments are given in Table 1.

Incorporation of $^{14}C_2H_4$ activity occurred to an extent of only 0·05 per cent of the input carbon-14 radioactivity, and the majority of this activity appeared in the organic acid fractions. Subsequent experiments with the fruit, in atmospheres of oxygen or nitrogen, failed to improve the amount of incorporation. Moreover, other experiments with ripe oranges, limes, papayas, green apples, tomatoes and

Table 1. Incorporation of Radioactivity from Ethylene-1,2-Carbon-14* into Pear and Avocado Fruits

Fruit	Radioactivity in c.p.m.
Avocado:	
Seeds:	
Ethanol extract	1,700
Peelings:	
Aqueous extract	3,000
Organic acids	2,740
Pulp:	
Aqueous extract	9,000
Organic acids	6,850
Respiratory CO_2	0
Pear:	
Peelings:	
Ethanol extract	5,000
Organic acids	3,520
Pulp:	
Aqueous extract	8,000
Organic acids	3,520
Amino-acids	0
Sugars and other neutrals	540
Respiratory CO_2	0

* Total activity of $^{14}C_2H_4$ was $2{\cdot}8 \times 10^7$ c.p.m. (specific activity $1{\cdot}4 \times 10^5$ c.p.m./m.mol.) used as ethylene–air mixture (1 : 1,000).

grapes failed to show any incorporation of ethylene radioactivity into these fruits.

The fact that ethylene can be incorporated into only two varieties of fruits, and even then the net amount of incorporation is extremely small, indicates that ethylene is probably a terminal product of a sequence of metabolic processes in fruit and cannot be further metabolized. This implies that the appearance of a small amount of $^{14}C_2H_4$ activity in fruit constituents is probably the result of exchange reactions in the biosynthetic sequence of ethylene in fruit. The fact that the majority of the incorporated activity was concentrated in the organic acid fractions of the fruit peelings and pulp further suggests that ethylene is probably synthesized by a route which is closely connected with organic acid metabolism. Therefore degradation studies were carried out on two organic acids isolated from these experiments.

After concentration of the ether extract of fruit pulp, the crude organic acids fraction of the avocado fruits previously exposed to ethylene-1,2-^{14}C was chromatographed on a silica gel column using increasing concentrations of *n*-butanol in chloroform[6]. The fractions representing the individual acids were combined and concentrated and fumaric and succinic acids were isolated from them in pure state. The purity and identity of all acid fractions were established by paper chromatography in pentanol/formic acid/water or butanol/acetic acid/water.

The specific activity of fumaric acid was determined by means of the wet combustion method. A portion of the acid was degraded according to the method of Allen and Ruben[7] and Foster *et al.*[8], in which fumaric acid was oxidized with acid permanganate at low temperature with a resulting conversion of all its carboxyl carbons and half its middle carbon atoms to carbon dioxide with the remaining half to formic acid. The formic acid was steam distilled from the reaction mixture and oxidized to carbon dioxide according to the method of Horowitz and King[9].

Table 2. Distribution of Radioactivity in Fumaric and Succinic Acids isolated from Avocado Fruits treated with Ethylene-1,2-Carbon-14

	Fumaric acid		Succinic acid	
	Specific activity c.p.m./ m.mol.	Per cent of total	Specific activity c.p.m./ m.mol.	Per cent of total
Whole molecule	234	100	104	100
Carbon number				
1		38·4		38·4
2		11·6		11·5
3		11·6		11·5
4		38·4		38·4

The activity of the entire succinic acid molecule was determined by wet combustion. The acid was degraded by high-temperature pyrolysis according to the method of Kushner and Weinhouse[10], yielding barium carbonate from the carboxyl carbons. The activity of C-2,3 was obtained by difference.

All samples were counted as barium carbonate in a gas flow counter to a statistical accuracy of 2 per cent.

Degradation of the isolated fumaric and succinic acids revealed a rather interesting labelling pattern (Table 2). Approximately three times as much carbon-14 activity was located in the carboxyl carbons of these acids as was found in the middle carbon atoms. Although it is impossible to tell from these isotopic distribution patterns the biosynthetic sequences of these fruits, the fact remains that the metabolic intermediate associated with ethylene in fruit must be closely related to the acids. The higher proportion of carbon-14 labelling in the carboxyl carbon atoms as compared to the middle carbon atoms of succinic and fumaric acids further suggests that ethylene is first incorporated into an unsymmetric intermediate compound in such a fashion that randomization has occurred preferentially in one of the carbon atoms in the ethylene skeleton.

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Incorporation of Nitrogen-15 in the 6-NH_2 Group of Adenosine Triphosphate by Muscle Extracts

It is well known that skeletal muscle extracts rapidly convert adenine nucleotides to inosine monophosphate; yet although the latter and other inosine nucleotides have been detected in muscle, the significance of these substances and their relation to metabolic and physiological activity have been

matters for controversy[1,2]. Parnas considered that reamination of inosine monophosphate was an oxidative process, as did Engelhardt[3] in his postulated adenylic cycle, whereas Nekhorocheff and Wajzer[4] have recently provided evidence that creatine can act as a precursor of the 6-NH_2 group of the adenine nucleotides.

Kalckar and Rittenberg[5] showed that after the administration of ammonium citrate labelled with nitrogen-15 to rats, the isotope was present in the 6-NH_2 group of the pooled adenine nucleotides which they considered to participate in reversible deamination reactions. Using ion exchange chromatography to isolate the adenine nucleotides from rabbit skeletal muscle after injection of ammonium citrate labelled with nitrogen-15, we have confirmed the findings of Kalckar and Rittenberg in that the 6-NH_2 group of adenosine triphosphate contained nitrogen-15. With cell-free homogenates of rabbit skeletal muscle, very low figures for the incorporation of isotope into adenosine triphosphate from ammonium chloride labelled with nitrogen-15 were obtained; but with aspartic acid labelled with nitrogen-15, the adenosine triphosphate fraction in both rabbit and pigeon muscle preparations contained up to 2·57 atoms per cent excess nitrogen-15. Incorporation occurred almost entirely in the 6-NH_2 group, for when a sample of the adenosine triphosphate thus produced containing 0·275 atom per cent excess nitrogen-15 was converted to adenosine monophosphate and then deaminated with myosin 5′-adenylic deaminase, the ammonia produced contained 1·35 atoms per cent excess nitrogen-15.

The incorporating system was associated with the sarcoplasmic fraction of muscle, and active preparations have been obtained in dialysed aqueous extracts of acetone-dried powders made from the supernatant obtained by high-speed centrifugation (20 min. at 16,000 *g*) of muscle homogenates. In these preparations, nitrogen-15 as ammonium chloride was not incorporated into the adenosine triphosphate fraction. It has not yet been possible to compare the efficiency of aspartic acid as a precursor of the 6-NH_2 group of adenosine triphosphate with other labelled amino-acids, but it is possible that adenine nucleotides are being produced in the muscle preparations from inosine monophosphate via the adenylosuccinate pathway suggested by Carter and Cohen[6] for the synthesis of adenosine monophosphate in yeast and for which there is evidence in other systems[7].

Determination of the synthesis of adenine nucleotides in muscle homogenates is complicated by the active 5′-adenylic deaminase which is present. The deaminase activity of acetone-dried powder extracts is low and in a system containing 5 m.molar adenosine triphosphate, 5 m.molar inosine monophosphate, 10 m.molar fructose diphosphate, 5 m.molar aspartic acid labelled with nitrogen-15 (60 atoms per cent excess), 5 m.molar magnesium chloride, 0·002 per cent diphosphopyridine nucleotide and 0·01 *M* phosphate buffer *p*H 7·5, there appears after incubation at 20° C. to be an increase in adenine nucleotides with a roughly equivalent decrease in inosine monophosphate. No adenylic acid can be detected in this system, which in 60 min. transfers about 10 per cent of the aspartic amino nitrogen to the adenosine triphosphate.

In so far as dialysed extracts of acetone-dried powders were used in our system, it seems unlikely that creatine or phosphocreatine, as suggested by Nekhorocheff and Wajzer, or β-alanine as proposed by Kometiani and Klein[8], were involved in the transfer of nitrogen to the 6-amino group of adenosine triphosphate.

We wish to thank Dr. G. H. Smith and Mr. B. Boon of this Department for their unfailing collaboration in carrying out a large number of nitrogen-15 determinations. We are also indebted to the Medical Research Council for a research training grant to one of us (A. A. N.) and for a grant towards expenses (to S. V. P.).

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Identification of Two Artefacts in an Alkaline Hydrolysate of Thyroid Tissue

In a previous paper the presence of a fast-running peak in a column chromatogram of an alkaline hydrolysate of rat thyroid was reported[1]. This peak, representing an unknown radioactive iodine compound, amounted to 2–5 per cent of the total radioactivity. Further examination of this component by paper chromatography in a *tert*-pentanol/2*N* ammonia (1 : 1) system disclosed the presence of two radioactive spots in approximately equal amounts. Both substances were readily extracted from aqueous solution with ether and were not absorbed by the acid form of the ion exchange resin 'Dowex 50'. Neither substance could be detected in ether extracts of thyroid homogenates. These properties suggested that the substances might be artefacts and this was confirmed by the finding that they had the same R_F values in an *n*-butanol/*n*-pentanol/ammonia system as the artefacts produced by Stanley[2] by heating 3-iodo- or 3 : 5-di-iodo-tyrosine in 2 *N* sodium hydroxide for 16 hr. at 105° C. Hydrolysis of N-acetyl-di-iodotyrosine or N-acetyl-mono-iodotyrosine in 2 *N* hydrochloric acid or sodium hydroxide for 1 hr. at 100° C. was found to be a quicker method of producing the artefacts, but in contrast to Stanley's finding, only one was produced from each substituted tyrosine. Sufficient material for identification was obtained by hydrolysis of 1 gm. of N-acetyl-di-iodotyrosine in 20 ml. 2 *N* sodium hydroxide. The hydrolysate was extracted twice with an equal volume of *n*-butanol and the concentrate applied in a band on three 10-cm. Whatman No. 1 papers and developed with *tert*-pentanol/ammonia. The artefact band was located under an ultra-violet lamp, cut out and eluted with methanol. After removal of the methanol the residue, about 5 mgm., was crystallized from acetic acid. Identity of the material as 3 : 5 di-iodo-4-hydroxybenzaldehyde was established by melting point and mixed melting point (201–202° C.) determinations. The identification was confirmed by comparison of the infra-red absorption spectra of the

isolated material and an authentic specimen. Similar treatment of N-acetyl-mono-iodotyrosine gave 3-iodo-4-hydroxybenzaldehyde, which was identified by the above procedure (m.p. and mixed m.p. 113–114° C.). Di-iodo-hydroxybenzaldehyde has been obtained previously from the hydrolysis products of iodinated casein, but could not be isolated from hydrolysed thyroid tissue[3].

In *tert*-pentanol/ammonia, *n*-butanol/dioxan/ammonia and *n*-pentanol/*n*-butanol/ammonia systems, which separate thyroxine and 3′ : 3 : 5-tri-iodothyronine, the mono-iodo aldehyde runs in the same position as tri-iodothyronine. In *n*-butanol/ammonia this aldehyde overlaps thyroxine and tri-iodothyronine, which are not separated, and in collidine/ammonia the two aldehydes run together near the solvent front.

I am indebted to Dr. J. Murray, of the Chemistry Department of this University, for the infra-red spectra determinations.

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Effect of Total Body X-Irradiation on the Respiration of the Homogenized Duodenal Mucosa of the Rat

WE have been endeavouring to examine the underlying biochemical processes involved in the development of radiation injury. We have selected intestinal, and especially duodenal, mucosa as experimental material, since it is highly sensitive to irradiation.

The morphological changes brought about by a single dose of 600 r. (170 kV.; 10 m.amp.; 0·5 mm. copper; 50 cm. focal distance; 25–30 r./min.) in rats are comparable with those described in the literature, as regards the weight changes of the duodenum, as well as the course of damage and rapid regeneration observed in the histological picture[1–3]. The duodenum was found to be free of bacteria at all times investigated after irradiation.

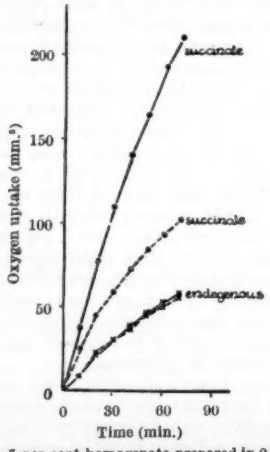

Fig. 1. 1 ml. 5 per cent homogenate prepared in 0·25 *M* sucrose; 75 μM phosphate buffer, pH 7·2; 3 μM adenosine triphosphate; 6 μM magnesium chloride; 30 μM succinate. Total volume, 3 ml. Incubated at 37° C. ———, Irradiated; – – – –, non-irradiated

The animals were killed at 1, 2, 16 and 20 hr., then at 1-day intervals following irradiation (196 animals). The duodenum was thoroughly washed with saline, mucosa was scraped off by means of a blunt knife and homogenized in 0·25 *M* sucrose in a Potter–Elvehjem homogenizer. In studies of the respiration of homogenized mucosa, it has been found that at 20 hr. after 600 r. total body radiation the rate of succinate oxidation increased to a level twice as high as that in the untreated controls and remained at that high level all through the 15-day observation period. A typical experiment is illustrated in Fig. 1, showing the situation at eight days after irradiation.

A few representative Q_{O_2} values are shown in Table 1 obtained at different times after irradiation.

Table 1

Q_{O_2} of			
non-irradiated controls		7–11 (32 animals)	
2 hr. post-irradiation		7–12 (5	,,)
5 days	,, ,,	16–28 (9	,,)
8	,, ,, ,,	15–26 (7	,,)
15	,, ,, ,,	18–26 (2	,,)

Irradiation has no similar effect on pyruvate or fumarate oxidation in a homogenate of duodenal mucosa.

Detrick *et al.*[3] have shown that in the rat exposed to a single total body dose of 600 r. the impairment of function (glucose absorption) does not run parallel with the histological changes (lesion and apparent restitution), the former being maintained even after histological repair is complete. A similar incongruence has been found to occur in the succinate oxidation of the duodenal mucosa.

Further studies are in progress at our laboratory aimed at a fuller elucidation of the mechanism of the above radiation-induced phenomenon. A fuller account of this work will be published elsewhere.

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Growth of Pancreatic Islet Tissue in the Anterior Chamber of the Eye

SINCE Minkowski[1] showed that the presence of a subcutaneous implant of a portion of pancreas would prevent the development of diabetes in an otherwise totally depancreatized dog, various investigators have observed the changes (histological and physiological) which follow the grafting of pancreatic tissue into different sites. Grafts have been made into the spleen, muscle coat of the intestines, stomach, cervical region[2] and abdominal wall[3]. In some cases autografts and in others homografts were made. Bottin[3], using dogs, anastomosed the pancreatic and carotico-jugular circulations in the neck but obtained a survival time of only a few hours. Simard[3], however, reported survival of islet tissue, neuro-insular

complexes and small amounts of acinar tissue for two months after transplantation of pancreas to the abdominal wall of the dog. Splenic grafts were unsuccessful.

The aim of the present work has been to obtain relatively pure mammalian islet tissue. In order to obtain the maximum number of islets per unit volume, fœtal pancreas was used. The risk of a homograft reaction was minimized by implanting the fœtal pancreas into the eye of the mother.

Twenty female Sprague Dawley and ten Wistar rats were used. A hysterotomy was performed under ether anæsthesia on the 16th–21st day of pregnancy. Two fœtuses were removed and the uterus and abdominal wound closed with catgut. A portion of the tail of the pancreas of one fœtus was inserted into the anterior chamber of the mother's eye. The other fœtus was used for histological purposes. Pancreatic tissue was taken from fœtuses of 19 mm. to full term, and in four cases it was obtained from day-old rats. Animals were killed at times up to six months after the insertion of the graft. Tissue was fixed in Bouin, paraffin sections were cut at 6μ and stained with hæmatoxylin and eosin or Gomori's aldehyde fuchsin. The oxidative stage of the Gomori reaction was modified in that sections were oxidized for 3–5 min. in equal parts of 1·0 per cent sulphuric acid and 0·1 per cent potassium permanganate; this weaker solution of permanganate does not discolour the sections and as a result the bisulphite bleach may be omitted. This modification has been found to give excellent staining of the β-cells of both adult and fœtal islets, with a marked reduction of the background staining which often attends the use of the original Gomori method[4] or Scott's modification[5] of it.

There was no operative mortality. All grafts were vascularized by the iris and persisted up to the time the animal was killed. Homograft reactions did not occur. Acinar tissue degenerated during the first month, and after this time islet tissue, adipose connective tissue, a few lymphocytes and a few ducts remained. The duct epithelium was low cuboidal.

In some cases the islets existed in more or less pure form and could be seen with the binocular dissecting microscope in the living animal, whereas others were embedded in connective tissue which often contained fat cells (Fig. 1). All islets had the typical appearance after hæmatoxylin and eosin and the β-cells gave a faint to strong positive Gomori reaction which contrasted with the absence of stain in the peripherally situated α-cells (Fig. 2).

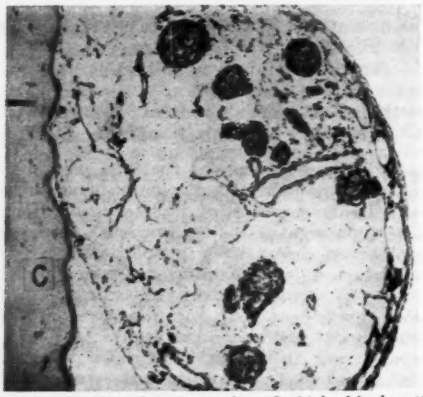

Fig. 1. Section through a pancreatic graft obtained by inserting portion of a day-old rat pancreas in the mother's eye. *C*, cornea. Islets of Langerhans are surrounded by adipose connective tissue. Hæmatoxylin and eosin. × 75

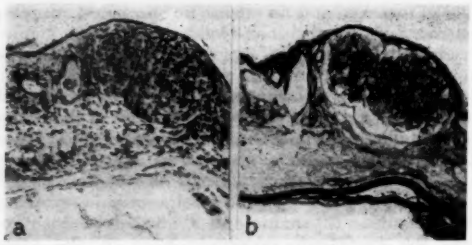

Fig. 2. (*a*) Discrete islet embedded in the iris. Graft obtained from a 32-mm. rat fœtus. Hæmatoxylin and eosin. × 100 (*b*) An adjacent section through the same islet stained with Gomori's aldehyde fuchsin. The cytoplasm of the β-cells is packed with stained granules; the unstained α-cells form a clear peripheral zone. × 75

The majority of this work was performed in the Department of Anatomy, University of Minnesota, and I wish to express my thanks to Dr. Arnold Lazarow, head of the Department, for his interest in this work and the facilities provided.

Rex E. Coupland

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Sept. 13.

[1] Minkowski, O., *Klin. Wschr.*, **29**, 90 (1892).
[2] Bottin, J., *C.R. Soc. Biol., Paris*, **121**, 872 (1936).
[3] Simard, L. C., *Rev. Canad. Biol.*, **2**, 453 (1943).
[4] Gomori, G., *Amer. J. Clin. Path.*, **20**, 665 (1950).
[5] Scott, H. R., *Stain Tech.*, **27**, 267 (1952).

Action of Schradan in the Cockroach

The insecticide schradan (octamethylpyrophosphoramide) is toxic to mammals and such insects as the aphid, squash bug and milkweed bug, but not to the cockroach, housefly, honeybee or Colorado beetle. However, the resistant are as active as the susceptible insects in their capacity to convert schradan to a potent anticholinesterase[1], now believed to be the hydroxymethyl derivative of schradan[2,3]. It was suggested previously[1] that this metabolite might not penetrate to the nerve cord, perhaps because of the relatively polar character of the compound, so that only that fraction of the schradan which penetrated to the cord and was there converted was effective in poisoning. As the resistant insects converted more schradan in non-nervous tissue, less was available for penetration to the cord, and it was suggested that this might be the cause of their resistance.

However, it was recently shown[3] that both the hydroxymethyl derivative and heptamethylpyrophosphoramide, the further degradation product of the hydroxymethyl derivative, are toxic to the squash bug and mouse, but not to the cockroach. Therefore schradan is not the only compound that can penetrate to the nerve cord of the squash bug; the hypothesis above must be incorrect.

A previously described technique[1] was used for showing that heptamethylpyrophosphoramide is converted to a potent anticholinesterase by whole cockroach gut, or by suitably fortified mouse-liver microsome preparations (Table 1). The requirements for conversion are the same as those previously shown for

Table 1

	Cholinesterase inhibition (per cent)
Heptamethylpyrophosphoramide (HMPA)	10
Cockroach gut + HMPA	40
Cockroach gut + HMPA (anaerobic)	10
Liver microsomes + co-factors + HMPA	52
Liver microsomes + co-factors + DPNH + HMPA	77
Liver microsomes + co-factors + HMPA (anaerobic)	30
Liver microsomes + HMPA	10

Each Warburg flask contains 1 ml. human plasma diluted × 2·5 (cholinesterase source) plus 1 ml. microsome preparation or tissue in 0·9 per cent potassium chloride, and co-factors were shown. After 1 hr., 0·3 ml. 2·52 per cent sodium bicarbonate is added, flasks are gassed with 5 per cent carbon dioxide in nitrogen. 30 min. later, 0·2 ml. 5 per cent acetyl choline bromide tipped in, carbon dioxide measured. HMPA, $7{\cdot}1 \times 10^{-4}$ *M*. DPNH, 4×10^{-4} *M*. Co-factors: Mg^{++} 0·015 *M*, DPN 4×10^{-4} *M*, nicotinamide 8×10^{-3} *M*. Tissue: 1 whole cockroach gut. Microsomes: precipitate at 40,000 *g* (30 min.) from supernatant produced by spinning 5 per cent mouse liver in 0·9 per cent potassium chloride at 10,000 *g* for 10 min. Washed once.

schradan oxidation[4]. This suggests a comparable reaction, and probably heptamethylpyrophosphoramide conversion also involves the oxidation of a dimethylamino group, yielding the 'second inhibitor', which has been observed in the permanganate oxidation products of schradan[3,5]. The conversion accounts for the unexpected toxicity of heptamethylpyrophosphoramide.

The problem of the non-toxicity of schradan to the cockroach was further investigated. Ten American cockroaches were each injected with 200γ of schradan. After 4·5 hr., they were homogenized, the proteins precipitated and the solution extracted with chloroform. The inhibitor thus obtained was assayed against the cholinesterase of (*a*) homogenized cockroach nerve cords and (*b*) excised cords. Similar inhibitions were found in both cases. A calculation was made assuming that the volume in which the insecticide might be distributed in a whole cockroach was 1 ml. It was calculated that at a dose of 200 γ/gm. there was 2·5 times as much inhibitor produced in the 4·5 hr. as was required to inhibit the nerve cord cholinesterase by 95 per cent—if the inhibitor acts against the intact as it does on the excised cord. Now, in fact, Metcalf *et al.*[6] have shown that even at 300 γ/gm. the enzyme *in vivo* is only 60 per cent inhibited. Also we find an LD_{50} for the cockroach of 1,340 γ/gm. This substantiates the previous suggestion that non-toxicity is not attributable to inadequate oxidation and suggests that *in vivo* the cord is protected from the effects of the metabolite.

Permanganate-oxidized schradan, which contains both heptamethylpyrophosphoramide and the hydroxymethyl derivative, was prepared as previously described[2]. A solution containing the oxidation products of 27 mgm. of schradan in 50 ml. of *tris*(hydroxymethyl)-aminomethane buffer (*p*H 8·2) was used. When this solution was incubated with excised nerve cords, the cholinesterase of the latter was inhibited 73 per cent (average). When the solution was incubated with eviscerated cockroaches containing an intact nerve cord, the cholinesterase was only inhibited 9 per cent. The experiments with eviscerated cockroaches were repeated, but the cord was fully exposed by dissection, without damaging it. A similar small inhibition was observed (8 per cent). However, if the exposed cords were damaged, much greater inhibitions were found. Thus if the lateral connexions to the three thoracic ganglia were severed, incubation with the solution gave 50 per cent inhibition. If the thoracic ganglia were each pierced deeply with a microscalpel before incubation, 69 per cent cholinesterase inhibition was found. In no case did damage followed by incubation in inhibitor-free buffer give any inhibition. These results show that the potent anticholinesterases produced by the cockroach following injection of schradan do not substantially inhibit the cholinesterase of the nerve cord because they fail to penetrate the cord. Experimental damage of the cord permits the compounds to enter and to produce strong inhibition. Presumably a protective barrier is involved. It is unlikely that the simple enzymic techniques described above will be suitable for study of the schradan-susceptible insects, in which one would expect the barrier to be absent or imperfect.

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E. Y. Spencer

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University Sub P.O.,
London, Ontario.
Oct. 9.

[1] O'Brien, R. D., and Spencer, E. Y., *J. Agric. Food Chem.*, **1**, 946 (1953).
[2] O'Brien, R. D., and Spencer, E. Y., *J. Agric. Food Chem.*, **3**, 56 (1955).
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[4] O'Brien, R. D., *Canad. J. Biochem. Physiol.*, **34**, 1131 (1956).
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Normal Levels of Plasma Thiocyanate

In the course of other experiments, values for the normal plasma concentration of thiocyanate were required for various species. Although values for man have often been reported, other species appear to have been little studied, and few reports exist of a series of estimations on a range of species using the same analytical method. One such series reported by Bacq and Fischer[1] does not include the common laboratory animals.

In the present work, the plasma thiocyanate concentrations of the mouse, rat, guinea pig, rabbit, cat and dog were determined. The analytical method used was that of Aldridge[2], which is based on the conversion of thiocyanate to cyanogen bromide, this being estimated colorimetrically by its reaction with benzidine in pyridine solution.

The results are given in Table 1, the thiocyanate being expressed as HCNS.

Table 1

Species	No. of animals	Mean HCNS (μgm./ml. plasma)	σ
Mouse	20	3·26	0·57
Rat	15	3·26	0·31
Guinea pig	9	8·39	1·72
Rabbit	11	2·67	0·54
Cat	3	2·18	0·42
Dog	6	1·13	0·13

The relatively high level of plasma thiocyanate in the guinea pig is of particular interest, especially since the animals were maintained on the same diet as the rabbits. Further work on the cause of this high level has yet to be done.

R. Holmes

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Porton, Wiltshire.
Oct. 23.

[1] Bacq, Z. M., and Fischer, P., *Bull. Soc. Chim. Biol.*, **29**, 308 (1947).
[2] Aldridge, W. N., *Analyst*, **69**, 262 (1944); **70**, 474 (1945).

Temporary Preservation of Carcasses of Small Laboratory Animals containing Radioactive Isotopes

The safe disposal of carcasses containing radioactive isotopes often presents a difficult problem. Even if a specially designed incinerator is available, it is still important that the amount of radioactive isotope in the material to be burned is kept as low as possible.

If animal carcasses containing short-lived isotopes (particularly iodine-131 and phosphorus-32) could be conveniently preserved for a sufficient time to reduce the radioactivity to relatively innocuous levels before incineration, the task of collecting and disposing of the radioactive ash would be avoided.

A procedure has been worked out for the preservation of whole carcasses or portions of tissue of animals not greater than 3 kgm. in weight by sealing them in polythene bags together with a mixture of fresh bleaching powder and 'Vermiculite' (a commercial expanded mica).

The following details are essential to the success of the process.

(1) It is desirable to slit the carcass ventrally along the mid-line, if this has not already been done, before placing it in the bag.

(2) If the carcass is soiled with tissue fluid or blood, it should be dusted with bleaching powder and allowed to cool before being placed in the bag. This avoids the development inside the bag of heat due to the rapid interaction of the bleaching powder and organic matter. The heating may also be avoided by applying 'Vermiculite' to the opened carcass. The finer grades of this material absorb about four times their weight of fluid, and thus the interaction with the bleaching powder is slowed down.

(3) The open end of the bag (which should be made of the heavier gauges, 250–500, of polythene) should have been previously folded back in a double cuff, fold outwards, to protect the surfaces to be sealed from dust or organic matter.

(4) The weights of bleaching powder and 'Vermiculite' should each be not less than one-fifth of the weight of the carcass. This represents, in practice, a volume of about 300 ml. and 1,500 ml., respectively, per kgm. weight of carcass.

(5) The animal's claws should be cut before the start of the radioactive experiment. The feet of the carcass should be bound with adhesive tape, lint or bandage before it is placed in the bag to avoid the risk of puncturing the bag; for the same reason it is unwise to sever the feet of the animal with bone forceps lest sharp splinters are left.

(6) The bag should be sealed with a suitable type of electrically heated 'soldering-gun' so that only a small amount of air is included; but care should be taken in expelling the air not to blow dust on the surfaces to be sealed.

(7) The 'cocooned' carcasses should be stored in open containers to allow for free circulation of air outside the bags, until the radioactive isotope has decayed sufficiently for incineration.

Experiments which have been in progress for sixteen months have demonstrated the practicability of the method. The cocooned carcasses have been stored during this time in open tins in a black-painted hut on the roof of the Department of Pathology. For a period of about eight weeks during the early part of the experiment the mean daily maximum shade temperature, as recorded in the nearby Geography School, was over 70° F., and the temperatures inside the hut were certainly greater than this. In spite of these unusually severe conditions there was never any obvious sign of putrefaction, although there was a persistent odour of 'bleaching powder' in the hut.

Tests have shown that the presence of the 'Vermiculite' does not seriously impede the progress of the combustion in a gas-fired incinerator.

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Oct. 5.

'Erythrocytin' and 'Erythrochelatin'

In a recent communication[1], Beckett and Smith have described a thermolabile inhibitor acting on 8-hydroxyquinoline ('Oxine'), which is either liberated or produced by erythrocytes and for which they have proposed the term 'erythrocytin'. To avoid confusion, my associates and I wish to direct attention to the fact that we have applied the same name to the clotting factor which we discovered in the erythrocytes[2]. This agent resembles the clotting principle occurring in the platelets, but is considerably more potent and has properties sufficiently characteristic to warrant regarding it as a distinct substance. We considered the name 'erythrocytin' particularly suitable because the ending 'in' is the same as in thromboplastin. The term has been employed in several of our publications[3–5] during the past year and in the titles of two of these communications[3,4].

Armand J. Quick
Department of Biochemistry,
Marquette University School of Medicine,
Milwaukee 3, Wisconsin.

[1] Beckett, A. H., and Smith, W. G., *Nature*, **178**, 742 (1956).
[2] Georgatsos, J. G., Hussey, C. V., and Quick, A. J., *Amer. J. Physiol.*, **181**, 30 (1955). Quick, A. J., Georgatsos, J. G., and Hussey, C. V., *Amer. J. Med. Sci.*, **228**, 207 (1954).
[3] Hussey, C. V., and Kaser, M., *Fed. Proc.*, **15**, 279 (1956).
[4] Quick, A. J., and Hussey, C. V., *J. Lab. and Clin. Med.*, **46**, 940 (1955).
[5] Quick, A. J., and Hussey, C. V., *Amer. Med. Assoc. Arch. Int. Med.*, **97**, 524 (1956).

We were unaware of the application by Dr. A. J. Quick and his associates during the past year of the hitherto unused term 'erythrocytin' to describe a clotting factor they discovered in erythrocytes. To avoid confusion attendant upon using the same term for two separate factors, we therefore propose renaming the factor we obtained from erythrocytes which inhibits the antibacterial activity of 8-hydroxyquinoline—a chelating agent. In future, we will therefore use the term 'erythrochelatin' instead of 'erythrocytin' to describe this inhibitor[1].

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W. G. Smith
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Bradford.

[1] Beckett, A. H., and Smith, W. G., *Nature*, **178**, 742 (1956).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, January 7

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Guy Arnold: "Oxford Expedition to Sarawak".

Monday, January 7—Tuesday, January 8

PHYSICAL SOCIETY (at Queen Mary College, Mile End Road, London, E.1)—Conference on "Crystal Dynamics".

Tuesday, January 8

SOCIETY OF DAIRY TECHNOLOGY (at the North Hall, Victoria Halls, Bloomsbury Square, London, W.C.1), at 10.30 a.m.—Meeting on "The Assessment of Cheese Quality".

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS (at 6 Buckingham Gate, London, S.W.1), at 5.30 p.m.—Mr. F. G. Sturrock and Mr. J. R. Warburton: "The Economics of Machinery Investment on the Farm".

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Presentation and discussion of papers entitled "An Investigation of the Transient Response of a Distillation Column". Part 1: "Solution of the Equations" by Mr. H. H. Rosenbrock; Part 2: "Experimental Work and Comparison with Theory" by Mr. W. D. Armstrong and Mr. W. L. Wilkinson.

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT and RADIO SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. R. B. R. Shersby-Harvie, Mr. L. B. Mullett, Mr. W. Walkinshaw, Mr. J. S. Bell and Mr. B. G. Loach: "A Theoretical and Experimental Investigation of Anisotropic-Dielectric-Loaded Linear Electron Accelerators".

INSTITUTION OF MECHANICAL ENGINEERS, AUTOMOBILE DIVISION (joint meeting with the HYDRAULICS GROUP, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. J. G. Giles: "A Review of Hydrokinetic Fluid Drives and their Possibilities for the British Motor Industry".

INSTITUTION OF THE RUBBER INDUSTRY (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. S. M. Ardley: "Phenolic Resins as Reinforcing Agents". 7 p.m.—Mr. A. E. Eagles and Mr. A. R. Payne: "Electronic Force Measurement in Rubber Testing".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. C. Maskell: "The Significance of Flow Separation in Three Dimensions".

ROYAL SOCIETY OF MEDICINE, PSYCHIATRY SECTION (at 1 Wimpole Street, London, W.1), at 8 p.m.—Dr. E. Grey Walter: "The Brain as a Machine", followed by a discussion opened by Dr. W. Ross Ashby.

Wednesday, January 9

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (joint meeting with the SOCIETY FOR APPLIED BACTERIOLOGY, in the Beveridge Hall, Senate House, University of London, W.C.1), at 2.15 p.m.—Discussion on "The Training of Microbiologists".

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Mr. C. M. Marsh: "Inland Waterways" (Vernon Harcourt Lecture).

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (in the restaurant room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Eighth London Discussion Meeting (Review Meeting).

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14–16 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. A. B. McIntosh: "Corrosion Problems in Nuclear Power Production".

Thursday, January 10

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Miss Miriam V. Griffith: "Some Aspects of Heat-Pump Operation in Great Britain, with particular reference to the Shinfield Installation".

ROYAL AERONAUTICAL SOCIETY (at Church House, Westminster, London, S.W.1), at 6.30 p.m.—Mr. E. T. Jones—Presidential Address.

INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Diagnosis of Causes of Plain Bearing Failure".

SOCIETY OF INSTRUMENT TECHNOLOGY, CONTROL SECTION (at Manson House, Portland Place, London, W.1), at 7 p.m.—Mr. F. T. Lett: "Electronic Automation of Machine Tools".

Friday, January 11

ASSOCIATION OF APPLIED BIOLOGISTS (in the Mining Lecture Theatre, Royal School of Mines, Prince Consort Road, London, S.W.7), at 10.50 a.m.—Symposium on "Wheat Bulb Fly".

INSTITUTION OF MECHANICAL ENGINEERS, INTERNAL COMBUSTION ENGINE GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. D. B. Spalding: "An Analogue for High-Intensity Steady-Flow Combustion Phenomena".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Mr. J. L. Winfield: "Problems in the Packaging of Fine Chemicals".

Saturday, January 12

QUEKETT MICROSCOPICAL CLUB (in the Botany Department, Royal College of Science, South Kensington, London, S.W.7), from 2 p.m. to 8 p.m.—Exhibition of Microscopy 1957.*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (with a degree in mathematics and teaching experience) IN THE MATHEMATICS DEPARTMENT—The Registrar, The Technical College, Sunderland (January 12).

PHYSICS GRADUATE IN THE DEPARTMENT OF RADIOTHERAPY, for duties which will include the physical investigations concerned with the clinical use of rotation therapy, multicurie cobalt units, low voltage X-rays and radioactive isotopes, and also some teaching of radiographer students—The Assistant Administrator, The Churchill Hospital, Headington, Oxford (January 12).

SENIOR TECHNICIAN IN THE CHEMICAL PATHOLOGICAL LABORATORY—The Group Secretary, North Middlesex Hospital, Edmonton, London, N.18 (January 12).

ASSISTANT DIRECTOR (with an academic qualification in agriculture and extensive practical agricultural experience) OF AGRICULTURE, Rarotonga, Cook Islands (Vacancy 2261)—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (January 19).

ASSISTANT IN ZOOLOGY (ENTOMOLOGY)—The Secretary of University Court, The University, Glasgow (January 31).

CHAIR OF PHYSICS in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

LECTURER IN STATISTICS IN THE DEPARTMENT OF MATHEMATICS—The Secretary, The University, 38 North Bailey, Durham (January 31).

LECTURER IN THE DEPARTMENT OF BOTANY and ASSISTANT CURATOR OF THE BOLUS HERBARIUM (University of Cape Town)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, also The Registrar, University of Cape Town, Rondebosch, Cape Town, South Africa (January 31).

LECTURER or ASSISTANT LECTURER IN ZOOLOGY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

ASSISTANTS IN CHEMISTRY—The Secretary of University Court, The University, Glasgow (February 1).

ENGINEER (COMPUTING) (with an honours degree in electrical engineering or physics, with experience particularly in electronic circuitry) at the University of Sydney, Australia, for work, under the supervision of the Senior Engineer, on the development and design of electronic computing equipment for use in association with the computing machine SILLIAC in the School of Physics—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 1).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 5).

I.C.I. RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, ENGINEERING, PHARMACOLOGY, PHYSICS or CHEMICAL TECHNOLOGY—The Secretary, The University, Edinburgh (February 16).

ASSISTANT LECTURER IN ZOOLOGY—The Principal, Royal Holloway College, Englefield Green, Surrey (February 18).

BIOCHEMIST, NON-MEDICAL (Basic grade), IN THE GROUP LABORATORY, Guildford—The Hospital Secretary, St. Luke's Hospital, Guildford.

BIOCHEMIST (with an honours degree of an approved university and at least three years postgraduate experience in biochemistry) IN THE MEDICAL DEPARTMENT, Government of Hong Kong, to undertake clinical biochemical analysis, mostly routine, with assistance; and to be in charge of biochemical work done for the Medical Department—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/51/040.

ENGINEER or PHYSICIST (young graduate, preferably with some mathematical ability and experience in the use of electronic instruments) for work in Sheffield on the problems of file testing and manufacture—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "F.3".

GRADUATE IN THE ERGONOMICS SECTION, to carry out research into the human engineering aspects of the design of control points in steelworks—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "ERG 1".

MATHEMATICAL PHYSICISTS AND MATHEMATICIANS (with a first- or second-class honours degree in mathematics or mathematical physics, preferably together with some years of postgraduate research experience) to work in one of the following fields: astrophysics, atmospheric diffusion, atomic physics, statistics or stochastic theory, statistical mechanics, reactor physics, fluid mechanics, solid mechanics or general applied mechanics, and numerical analysis involving the use of large digital computers—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1320/34.

POSTDOCTORATE FELLOWS IN FUNDAMENTAL RESEARCH IN SCIENCE AND ENGINEERING—The Secretary, The Advisory Committee on Scientific Research, University of Toronto, Toronto, Canada.

RESEARCH TECHNICIAN (with a sound knowledge of electronics (amplifier circuits and display methods) and preferably biological experience) at the M.R.C. Laboratories, Hampstead, for electrophysiological research—The Personnel Officer, National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7.

SENIOR TECHNICIAN (with experience in preparing medical and dental student pharmacological experiments, capable of general maintenance of departmental equipment and assisting with physiological or biochemical research)—The Chairman, Department of Pharmacology, McGill University, Montreal, Canada.

TECHNICAL OFFICER (with H.S.C. or G.C.E. (A) in mathematics and physics, and preferably with experience in meteorology) in the East Africa High Commission Meteorological Department—The Crown Agents, 4 Millbank, London, S.W.1, quoting M3B/43104/NF.

TECHNICIAN (preferably with G.C.E. in science subjects at advanced level, or similar qualifications) to assist in staff radiation protection services—The Secretary, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

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